AN OVERVIEW OF THE BUDGET PROPOSAL FOR THE DEPARTMENT OF ENERGY FOR FISCAL YEAR 2019

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

MAY 9, 2018

Serial No. 115–58

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE
30–321PDF WASHINGTON : 2019

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CONTENTS

May 9, 2018

AN OVERVIEW OF THE BUDGET PROPOSAL FOR THE DEPARTMENT OF ENERGY FOR FISCAL YEAR 2019

WEDNESDAY, MAY 9, 2018

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to call, at 9:04 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Lamar Smith [Chairman of the Committee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

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Full Committee

An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

Wednesday, May 9, 2018
9:00 a.m.
2318 Rayburn House Office Building

Witness

The Honorable Rick Perry, Secretary, Department of Energy

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Wednesday, May 9, 2018

TO: Members, Committee on Science, Space, and Technology

FROM: Majority Staff, Committee on Science, Space, and Technology

SUBJECT: Full committee hearing: "An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019"

The Committee on Science, Space, and Technology will hold a hearing titled *An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019* on May 9, 2018 at 9:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of this hearing is to examine the Department of Energy (DOE) fiscal year (FY) 2019 budget request to Congress and the impact this proposed funding could have on civilian research, development, demonstration, and commercial application programs at the Department. This hearing will also address the Administration's plans for implementing the FY 2018 enacted appropriations and future funding priorities at the Department.

Witness List

- **The Honorable Rick Perry**, Secretary, Department of Energy

Staff Contact

For questions related to the hearing, please contact Hillary O'Brien of the Majority Staff at 202-226-8984.

Chairman SMITH. The Committee on Science, Space, and Technology will come to order.

Without objection, the Chair is authorized to declare recesses of the Committee at any time.

Welcome to today's hearing entitled "An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019."

First of all, I'd like to thank Secretary Perry for being here today. And just as a reminder to everyone, this committee has jurisdiction over all of the Department of Energy's civilian research and development. That's $10 billion or about 1/3 of their budget.

I do want to say to Members that the Secretary has to leave at 10:30 sharp in order to get to a meeting at the White House, and so I'm going to do two things so that we'll make sure we have plenty of time for Members to ask questions. One, I'm going to put my opening statement into the record and also would like to limit questioning to four minutes per person, and that way I think we'll have time for everybody.

At this point I'll recognize the Ranking Member, the gentlewoman from Texas, for her opening statement.

[The prepared statement of Chairman Smith follows:]

COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
May 9, 2018

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(202) 225-6371

Statement by Chairman Lamar Smith (R-Texas)

An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

Chairman Smith: Today we welcome Secretary of Energy Rick Perry to testify about the Department of Energy's (DOE) fiscal year 2019 budget request and priorities.

Before he joined the administration in 2017, Secretary Perry served as the 47th Governor of Texas and under his direction, the state of Texas became a national leader in energy innovation and economic growth.

DOE is the leading federal sponsor of research in the physical sciences and a world leader in technological development and early stage scientific research.

The department funds research across the scientific disciplines and is responsible for groundbreaking discoveries in computing, manufacturing and medicine.

The House Science, Space, and Technology Committee has jurisdiction over $10 billion in spending at DOE—approximately one third of its overall budget—including all civilian research, development, demonstration and commercial application programs and the 17 DOE National Laboratories.

Our discussion with the secretary this morning will focus on programs within this broad jurisdiction, particularly the funding priorities in the president's fiscal year 2019 budget for the department.

This hearing also provides committee members with the opportunity to discuss the fiscal year 2018 enacted budget, which was signed into law earlier this year.

The budget proposes only $75 million in U.S. contributions to the ITER project, less than what is required to maintain U.S. participation in this world-leading international research collaboration.

The potential benefits from fusion research are incalculable, and commercial fusion will revolutionize the energy market and significantly reduce global emissions when it is developed.

However, the administration has proposed increased investments in the research infrastructure that will be necessary to maintain America's leadership in science.

For example, the budget request includes an increase in funding for the Advanced Scientific Computing Research (ASCR) program.

Within ASCR, a large portion of the requested fiscal year 2019 funding is designated for a DOE Exascale Computing Initiative.

Developing an exascale system is critical to enabling scientific discovery, strengthening national security and promoting U.S. industrial competitiveness. As of November 2017, the United States hosts only four of the top ten fastest supercomputers in the world, none of which are in the top three.

As other countries race to develop exascale systems of their own, DOE investment in exascale computing is essential to reestablish U.S. leadership in this field.

DOE also must invest in next generation research infrastructure at its world-renowned national laboratories.

In February, the House passed three committee bills that prioritize new investments and upgrades for the national labs. This includes funding for the Versatile Neutron Source, a fast test reactor that is critical for the development of advanced nuclear reactors.

The president's fiscal year 2019 budget includes funding for six of the eight facilities and upgrades included in this legislation.

While the funding levels do not reach the amounts authorized in the committee's legislation for fiscal year 2019, prioritizing these DOE user facilities in the budget request is an important first step for funding next generation science.

The president's request includes increased reliance on the private sector to drive commercialization of energy technologies. This ensures the department will focus limited research funds on the early-stage research that the private sector cannot perform.

We look forward to hearing from Secretary Perry today about how he plans to execute DOE's mission objectives in the upcoming fiscal year and beyond. Maintaining U.S. leadership in science will require a shared commitment to prioritize DOE research and support the next generation of energy technology.

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Ms. JOHNSON. Thank you very much, Mr. Chairman.

Before I begin my statement, I want to welcome to the full Committee Mr. Conor Lamb, who is one of our newest elected. And this is a very dynamic Committee, as you will understand later and could be better. A lot of Texans on this committee.

Thank you, Mr. Chairman, for holding the hearing, and thank you, Secretary Perry, for finally appearing before us today. And it's good to see you again, our longest-serving Texas Governor. And I knew him every day of it.

As you know, this committee has jurisdiction over the Department of Energy's vitally important science and energy research and development activities, the laboratories and facilities, so I hope we can see you much more frequently because we need your input, and I look forward to working with you for years to come.

In that spirit, I'd like to highlight some remarks you have made recently that I appreciate and wholeheartedly agree. In the address to the ARPA–E Energy Innovation Summit in March, you told the audience that you hoped they would, and I quote, "enjoy the many high-potential, high-impact technologies that ARPA–E has moved out of the lab and toward deployment." That's also one of the areas that I have great interest.

You also announced that ARPA–E projects have attracted more than $2.6 billion in private-sector follow-up funding. Seventy-one projects have formed new companies, and 109 have gone on to partner with other government agencies to further their research. And you went on to say that—and again I quote—"ARPA–E is one of the reasons DOE has had and is having such a profound impact on American lives."

Secretary Perry, you have been singing my song. And yet, as I'm sure you're aware, you made these remarks just a few weeks after the Administration proposed to eliminate ARPA–E for the second year in a row. You're also proposing a 70 percent cut to research carried out by DOE's Office of Energy Efficiency and Renewable Energies, a 37 percent cut to the Offices of Electricity and Nuclear Energy, and 31 percent cut to fossil fuel energy R&D.

And last but certainly not least, you are again proposing to eliminate DOE's remarkably successful Loan Programs Office, which has been instrumental in launching the utility-scale PV industry, the construction of our first new nuclear reactors in 30 years and announced, and are now supporting the commercialization of new carbon capture and reuse technologies for fossil fuel fossil energy system.

And so I have to ask, given your consistent praise for ARPA–E and DOE's energy technology and innovation programs more broadly throughout your tenure as Secretary of Energy to date, how do we make sense of this budget request? The Department's arguments about the value of these activities fall on deaf ears at OMB. Did you even push back on any of these ill-conceived draconian cuts at all?

By all credible accounts, American industry will not fund the activities that are proposed for elimination no matter how much the Administration would like to think so. The Department could have heard from industry directly, but for the second year in a row, we heard from the Department officials that they did not formally en-

gage with the private sector in deciding what activities we would cut—you would cut. And yet, that did not stop you from rationalizing these large cuts by simply stating that the federal role in our energy innovation pipeline should be strictly limited to support for so-called early-stage research without providing any clear definition for what that actually means.

And then over and over again in this request you state that the private sector is better suited to carry out anything that you're proposing to cut or eliminate entirely. But if you don't have any process to engage with the private sector before proposing to cut energy efficiency programs by 84 percent and then you'll have to excuse me if I find it difficult to take your justification for this budget request seriously.

Now, to be clear, I'm not saying that every program the Department currently implements is perfect. We should continue to identify small reforms and debate our priorities. We must be thoughtful investors of taxpayers' dollars. But I'm confident that investing robustly in our national laboratories and early and appropriately reviewed later-stage R&D is the right decision.

With that, I'd like to thank you again for being here, and I look forward to a productive discussion this morning.

I yield back, Mr. Chairman.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT
Ranking Member Eddie Bernice Johnson (D-TX)
Committee on Science, Space, and Technology

An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019
Full Committee Hearing
May 9, 2018

Thank you, Mr. Chairman for holding this hearing, and thank you, Secretary Perry, for finally appearing before us today. It is good to see you again. As you know, this Committee has jurisdiction over all of the Department of Energy's vitally important science and energy research and development activities, laboratories, and facilities, so I hope we see you much more frequently from now on, and I look forward to working with you in the years to come.

In that spirit, I would like to highlight some remarks you've made recently that I appreciate and wholeheartedly agree with. In your address to the ARPA-E Energy Innovation Summit in March, you told the audience that you hoped they would, and I quote, "enjoy the many high-potential, high-impact technologies that ARPA-E has moved out of the lab and towards deployment". You also announced that "ARPA-E projects have attracted more than 2.6 billion dollars in private sector follow-on funding. 71 projects have formed new companies, and 109 have gone on to partner with other government agencies to further their research." And you went on to say that, and again I quote, "ARPA-E is one of the reasons DOE has had and is having such a profound impact on American lives."

Secretary Perry, you've been singing my song. And yet, as I'm sure you are well aware, you made these remarks just a few weeks after the Administration proposed to eliminate ARPA-E for the second year in a row. You're also proposing a 70% cut to research carried out by DOE's Office of Energy Efficiency and Renewable Energy, a 37% cut to the Offices of Electricity and Nuclear Energy, and a 31% cut to fossil energy R&D.

And last but certainly not least, you are again proposing to eliminate DOE's remarkably successful loan programs office, which has been instrumental in launching the utility-scale PV industry, the construction of our first new nuclear reactors in 30 years, and is now supporting the commercialization of new carbon capture and reuse technologies for fossil energy systems.

So I have to ask, given your consistent praise for ARPA-E and DOE's energy technology and innovation programs more broadly throughout your tenure as the Secretary of Energy to date, how do we make sense of this budget request? Did the Department's arguments about the value of these activities fall on deaf ears at OMB, or did you even push back on these ill-conceived, draconian cuts at all?

By all credible accounts, American industry will not fund the activities that are proposed for elimination, no matter how much the Administration would like to think so. The Department could have heard that from industry directly, but for the second year in a row, we heard from Department officials that they did not formally engage with the private sector in deciding what activities you would cut. And yet that did not stop you from rationalizing these large cuts by

simply stating that the federal role in our energy innovation pipeline should be strictly limited to support for so-called "early-stage" research, without providing any clear definition for what that actually means. And then, over and over again in this request, you state that the private sector is better suited to carry out anything that you are proposing to cut or eliminate entirely. But if you don't have any process to engage with the private sector before proposing to, say, cut energy efficiency programs by 84%, then you'll have to excuse me if I find it difficult to take your justifications for this budget request seriously.

Now to be clear - I am not saying that every program the Department currently implements is perfect. We should continue to identify smart reforms and debate our priorities. We must be thoughtful investors of taxpayer dollars. But I am confident that investing robustly in our national laboratories in early *and* appropriately reviewed later-stage R&D is the right decision.

With that, I would like to thank you again for being here, Mr. Secretary, and I look forward to a productive discussion this morning. I yield back.

Chairman SMITH. Thank you, Ms. Johnson.

And I'll introduce our only expert witness today, who is Rick Perry, the 14th Secretary of the United States Department of Energy. Secretary Perry attended Texas A&M University, where he was a member of the Corps of Cadets and one of A&M's five Yell Leaders. After graduation, he was commissioned and served in the United States Air Force. He flew C–130 tactical airlifts in Europe and the Middle East until 1977 when he retired with the rank of Captain and returned to Texas to enter the cotton farming business with his father.

Secretary Perry served in the Texas House of Representatives and then as Texas Commissioner of Agriculture. He was elected Lieutenant Governor of Texas in 1998 and assumed the governorship in December 2000 when then-Governor George Bush resigned to become President of the United States.

In 2002, he was elected the 47th Governor of the Lone Star State. As the longest-serving Governor in Texas history, Secretary Perry oversaw the world's 12th-largest economy from 2000 to 2015. Under his leadership, Texas set the pace for job creation, innovation, and population growth. During his tenure, Texas improved air quality while reducing emissions and carbon dioxide, sulfur dioxide, and nitrogen oxide.

Besides guiding the Department of Energy, Secretary Perry also manages the 17 national laboratories, home to the country's best scientists and engineers.

I've had the privilege of working with Secretary Perry for over 30 years and very much appreciate his testifying before the Science Committee today. We look forward to his insights on the future of American energy and innovation.

Governor, welcome. We look forward to your comments.

TESTIMONY OF HON. RICK PERRY, SECRETARY, DEPARTMENT OF ENERGY

Secretary PERRY. Thank you, Mr. Chairman.

Ranking Member Johnson, it's a privilege to be in front of you again. She's been mentoring me for nearly 30 years, so it's good to be back with you and an honor to appear before all of you today to discuss the President's 2019 budget request for the Department of Energy.

And, as an aside, let me just say I really appreciate your understanding and your flexibility, the Cabinet meeting that's been called, and so in respect to your time and for us to be as productive as we can, I'll try to keep my remarks and my answers as brief as I can to save us time.

This fiscal year 2019 $30.6 billion budget request will help the Department of Energy fulfill the key objectives that is accelerating exascale computing, fostering and furthering our scientific and technological mission, modernizing our nuclear arsenal, addressing our Cold War environmental legacy, advancing energy production, and better protecting our infrastructure.

I'd like to briefly highlight the outstanding work. Mr. Foster, you represent one of the 17 national labs, and we had the opportunity to go out to your area and look at one of them. And not a greater I think cheerleader do we have, supporter of Fermi and Argonne

and the other 15 labs than you. These are incubators of innovation, and they are among America's greatest treasures.

And I also want to highlight the DOE's supercomputing and other advanced technologies that are going to play a crucial role in confronting threats to our energy and national security infrastructure and to maintaining America's leadership in science and medicine.

There is no more appropriate place for this kind of massive computing power than in America's lead science agency, and that's the Department of Energy. And we also must regain leadership in the broader area of STEM, science, technology, engineering, and math. Through our STEM Rising initiative and related activities, our Department is promoting STEM programs, collaborating with students and teachers at every level of education.

We also have a duty to advance our entire—I should—excuse me, our energy security by pursuing American energy independence because we are innovating more. We're regulating less. We are producing more energy from more diverse sources more efficiently than anyone ever predicted a few short years ago. We're now the number one combined oil and gas producing country in the world. I mean, that's fascinating when you think 15 years ago—Mr. Rohrabacher, I mean, this is a stunning development. Just last year, we became a net exporter of natural gas. Today, we are exporting LNG to 27 countries on five continents.

And thanks to that same innovation and that same drive, we are producing more energy cleaner than ever before. In fact, from 2005 to 2017 our economy was growing, and we led the world in reducing carbon emissions, cutting them by 14 percent over that period of time. Clearly, we don't have to choose between growing our economy and protecting our environment, but to achieve more complete energy security, we must ensure our energy actually gets delivered without interruption. And so my greatest focus as Energy Secretary is to ensure the reliability and resilience of our energy grid.

So this year, we've requested a funding increase to strengthen cybersecurity, cyber defenses. We're establishing a new office. It goes by the acronym of CESER, Office of Cybersecurity, Energy Security, and Emergency Response, CESER. In the end, it will be you, though, our elected representatives, who will decide how to best allocate the resources of our hardworking taxpayers. And I look forward to not only answering your questions but working with you, taking your advice as we go forward to make this agency even more efficient and better prepared for the future.

Thank you, Mr. Chairman.

[The prepared statement of Secretary Perry follows:]

Testimony of Secretary Rick Perry
U.S. Department of Energy
Before the
U.S. House Committee on Science, Space, and Technology
May 9, 2018

Chairman Smith, Vice Chairman Lucas, Ranking Member Johnson, and Members of the Committee, it is an honor to appear before you today to discuss the President's FY 2019 Budget Request for the Department of Energy ("the Department" or "DOE").

It is a privilege and an honor to serve as the 14th Secretary of Energy.

This budget represents a request to the American people through their representatives in Congress to fund the priorities of this Department.

As such, it represents a commitment from all of us at DOE– that we will honor the trust of our citizens with stewardship, accountability and service.

As Ronald Reagan reminded us in his First Inaugural, "We are a nation that has a government – not the other way around."

Last year, I committed to modernize our nuclear weapons arsenal, protect our energy infrastructure from cyber and other attacks, achieve exascale computing, advance strong domestic energy production, and address obligations regarding nuclear waste management and the Nation's nuclear legacy.

This FY 2019 $30.6 billion Budget Request for the Department of Energy ("Budget") delivers on these commitments.

The Department's world-leading science and technology enterprise generates the innovations to fulfill our mission. Through our 17 National Laboratories, we engage in cutting-edge research that expands the frontiers of scientific knowledge and generates new technologies to address our greatest challenges.

Our National Laboratories are doing outstanding work in many areas, and they have a rich history of innovation that has bettered the lives of millions across the globe. For example, in FY 2017, the National Laboratories won 33 of the prestigious R&D 100 Awards, including technologies regarding new materials, protecting our environment, incorporating renewable energy reliably on to our electric grid, and sophisticated cybersecurity tools. These are but a few examples of the work the National Laboratories have done just last year to push the boundaries of research,

development, and commercialization. I have had the opportunity to visit many of the Laboratories over the past year, and witness first-hand this outstanding work done by the dedicated workforce across the nation.

I am especially proud of how our National Laboratories, in working with the Department of Veteran's Affairs and other federal agencies, universities, doctors, and researchers, are harnessing the power of our world-class supercomputers to improve the health of our veterans. This work is part of DOE's proud legacy in the biosciences, and as the initiator of the Human Genome Project.

This Budget proposes over $12 billion in early stage research and development (R&D) that will focus the intellectual prowess of our scientists and engineers on the development of technologies that the ingenuity and capital of America's entrepreneurs and businesses can convert into commercial applications and products to improve the lives and security of all Americans.

Restoring the Nuclear Security Enterprise

The security of the United States and its allies is one of our primary DOE missions.

The Budget fulfills the President's vision of rebuilding and restoring our Nation's security through robust investments in the Department's nuclear security mission. The Budget provides $15.1 billion for the National Nuclear Security Administration (NNSA), $2.2 billion or 16.7 percent above the FY 2017 enacted level.

The Request makes necessary investments consistent with the February 2018 Nuclear Posture Review (NPR) to modernize and rebuild a nuclear force and nuclear security enterprise; prevent, counter, and respond to nuclear proliferation and terrorism threats; and provide safe, reliable, and long-term nuclear propulsion to the Nation's Navy.

The Budget includes $11.0 billion for Weapons Activities. This $1.8 billion increase over the FY 2017 enacted level supports maintaining the safety, security, and effectiveness of the nuclear stockpile; continuing the nuclear modernization program; and modernizing NNSA's nuclear security infrastructure portfolio in alignment with the NPR.

The Budget includes $1.9 billion for our ongoing Life Extension Programs (LEP) and Major Alterations, a $580 million increase. Funding for the W76-1 warhead LEP supports the Navy and will keep the LEP on schedule and on budget to complete production in FY 2019. An increase of $178 million for the B61-12 LEP will keep us on schedule to deliver the First Production Unit (FPU) in FY 2020 to consolidate four variants of the B61 gravity bomb and improve the safety and security of the oldest weapon system in our nuclear arsenal.

The Budget also supports the Air Force's Long-Range Stand-Off program through an increase of $435 million from FY 2017 enacted for the W80-4 LEP, to deliver the first production unit in FY 2025 of the cruise missile warhead. We also increase funding by $23 million for the W88 Alteration 370 to provide the scheduled first production unit in FY 2020. The request includes $53 million for a replacement for the W78, one of the oldest warheads in the stockpile, by 2030.

The Budget for Weapons Activities also increases investments to modernize our nuclear infrastructure. For example, we include $703 million, a $128 million increase from FY 2017, for construction of the Uranium Processing Facility needed to replace deteriorating facilities at the Y-12 National Security Complex, as well as $27 million for a Tritium Production Capability at Savannah River and $19 million for a Lithium Production Capability at Y-12.

The Weapons Activities Budget request also includes $163 million, a $68 million increase from FY 2017 enacted, for NNSA collaboration with the Office of Science on the development of exascale computer systems, which I address below.

In the NNSA's Naval Reactors program, the Department has the ongoing responsibility to provide militarily effective nuclear propulsion plants for Navy vessels and to ensure their safe, reliable and long-lived operation. The Budget provides $1.8 billion to support the safe and reliable operation of the Navy's nuclear-powered fleet and continuation of the *Columbia*-class submarine program, refueling of the Land-Based Prototype reactor, and the Spent Fuel Handling Recapitalization Project.

Today, over 45% of the Navy's major combatants are nuclear powered. DOE's role in propulsion plants, spent fuel handling, and recapitalization is critical to the Navy's ability to conduct its mission around the globe.

The Budget also includes $1.9 billion for the Defense Nuclear Nonproliferation (DNN) program to reduce global threats from nuclear weapons. This critical national security program prevents the spread of nuclear and radiological materials,

advances technologies that detect nuclear and radiological proliferation worldwide, and eliminates or secures inventories of surplus materials and infrastructure usable for nuclear weapons.

The Budget continues termination activities for the Mixed Oxide Fuel Fabrication Facility project proposed in the FY 2018 Request, providing $220 million for use toward an orderly and safe closure of the project. The Budget also includes $59 million for the continuation of preliminary design and the initiation of long-lead procurements for the Surplus Plutonium Disposition project in support of the dilute and dispose strategy.

The Budget provides $319 million for Nuclear Counterterrorism and Incident Response, $47 million above FY 2017 enacted, to work domestically and around the world to improve our ability to respond to radiological or nuclear incidents, in conjunction with other agencies in a broader U.S. Government effort.

Finally, the Budget includes $423 million for the federal workforce at the NNSA. This $35 million increase is essential to ensuring our world-class workforce of dedicated men and women can effectively oversee NNSA's critical national security missions.

Securing against Cyber Threats

Among the most critical missions at the Department is to develop science and technology that will ensure Americans have a resilient electric grid and energy infrastructure. Protecting this infrastructure means it has to be resilient and secure to defend against the evolving threat of cyber and other attacks.

Unfortunately, cyberattacks pose an ever-increasing threat to the Nation's networks, data, facilities, and infrastructure. A reliable and resilient power grid is critical to U.S. economic competiveness and leadership, and to the safety and security of the nation. We need to understand the increasing and evolving natural and man-made threats and develop the tools to respond to those threats across our energy infrastructure.

The Department is the sector-specific agency for the energy sector, and therefore, is the lead federal agency for the Emergency Support Function #12 that partners with the energy sector to ensure infrastructure security and resilience and to coordinate response and recovery. To elevate the Department's focus on energy infrastructure protection, the Budget Request splits the Office of Electricity Delivery and Energy Reliability, which totals $157 million, into two offices. Doing

so will increase focus on grid reliability in the Office of Electricity Delivery (OE) and cybersecurity in the Office of Cybersecurity, Energy Security, and Emergency Response (CESER).

CESER will allow more coordinated preparedness and response to emerging cyber and physical threats and natural disasters and support the Department's national security responsibilities. To work toward this critical objective, the Budget provides $96 million for the CESER office to develop tools needed to protect the U.S. energy sector against threats and hazards, mitigate the risks and the extent of damage from cyberattacks and other disruptive events, and improve resilience through the development of techniques for more rapid restoration of capabilities.

CESER will work in an integrated manner with private industry, as well as Federal, State, and Local jurisdictions and other DOE offices, to enable industry to enhance the resilience (the ability to withstand and quickly recover from disruptions and maintain critical function) and security (the ability to protect system assets and critical functions from unauthorized and undesirable actors) of the U.S. energy infrastructure.

Also, in FY 2019, the Office of Nuclear Energy's budget includes $5 million for the Nuclear Energy Enabling Technologies (NEET) Crosscutting Technology Development (CTD) program to expand its nuclear reactor cybersecurity research to support development of intrusion-resistant systems and practices. Research will be conducted in four areas: cyber risk management, secure architectures, modeling and simulation, and supply chain cyber security assurance. NEET-CTD will also perform simulated cyber-attacks against existing and next generation control system architectures to verify attack difficulty and control efficacy, methods, and metrics.

Securing against cyber threats means we must also protect against threats to the Department's own infrastructure in science, technology, and nuclear security. This Budget takes major steps to safeguard DOE's enterprise-wide assets against cyber threats. The Budget provides funding to secure our own networks, and increases funding for the Chief Information Officer by $16 million from the FY 2017 enacted level to modernize infrastructure and improve cybersecurity across the DOE IT enterprise. Funding for cybersecurity in the National Nuclear Security Administration is increased to $185 million to enhance security for our nuclear security enterprise. In the Environmental Management program, we provide $43 million for cybersecurity to ensure the security at seven cleanup sites. This Budget provides the resources we require to secure our systems and our infrastructure.

Improving Grid Resilience

As we protect our energy infrastructure from cyber threats, we also must improve resilience and reliability of the nation's electricity system. The Budget provides $61 million for Electricity Delivery to support transmission system resource adequacy and generation diversity, move forward with new architecture approaches for the transmission and distribution system to enhance security and resilience, and advance energy storage. The Budget supports research and development at DOE's National Laboratories to develop technologies that strengthen, transform, and improve energy infrastructure so that consumers have access to reliable and secure sources of energy.

Advancing Exascale and Quantum Computing

As I discussed last year, the Department's leadership in developing and building the world's fastest computers has faced increasingly fierce global competition over the last decade. Maintaining the Nation's global primacy in high-performance computing is more critical than ever for our national security, our continuing role as a science and innovation leader, and our economic prosperity.

The Budget includes $636 million to accelerate development of an exascale computing system, including $473 million in the Office of Science (Science) and $163 million in NNSA. This unprecedented investment, which is $376 million—or 145 percent—above the FY 2017 enacted level, reflects the Department's plan to deliver an exascale machine for the Office of Science in 2021 and a second machine with a different architecture by 2022.

To achieve these goals, the Science/NNSA partnership will focus on hardware and software technologies needed to produce an exascale system, and the critical DOE applications needed to use such a platform. This world-leading exascale program will bolster our national security by supporting the nuclear stockpile, while also supporting the next generation of scientific breakthroughs not possible with today's computing systems.

We will not, however, satisfy our need for computing advances with the achievement of exascale computing alone. The FY 2019 Budget Request also includes $105 million in quantum computing to address the emerging urgency of building our competency and competitiveness in the developing area of quantum information science. This early-stage, fundamental research will concentrate on accelerating progress toward application of quantum computing techniques and quantum sensing to grand challenge science questions.

Addressing the Imperative of Nuclear Waste Management

As I mentioned to this Committee last year, we must move ahead in fulfilling the Federal Government's responsibility to dispose of the Nation's nuclear waste. The Budget includes $120 million, including $30 million in defense funds, to resume licensing for the nuclear waste repository at Yucca Mountain and implement a robust interim storage program.

The Budget devotes $110 million for DOE to support the Nuclear Regulatory Commission (NRC) licensing proceeding for the nuclear waste repository at Yucca Mountain, including funding for technical, scientific, legal and other support.

In addition, the Budget includes $10 million to implement a robust interim storage program to ensure earlier acceptance of spent nuclear fuel and accelerate removal from sites in 39 states across the country. Interim storage capability also adds flexibility to the system that will move materials from sites across the country to its ultimate disposition.

By restarting the long-stalled licensing process for Yucca Mountain and committing to establishing interim storage capability for near-term acceptance of spent nuclear fuel, our Budget demonstrates the Administration's commitment to nuclear waste management and will help accelerate fulfillment of the Federal Government's obligations to address nuclear waste, enhance national security, and reduce future burdens on taxpayers. This also will increase public confidence in the safety and security of nuclear energy, thus helping nuclear energy to remain a significant contributor to the country's energy needs for generations to come.

Fulfilling Legacy Cleanup Responsibilities

The Budget also includes $6.6 billion for Environmental Management (EM), $182 million above the FY 2017 enacted level, to address its responsibilities for the cleanup and disposition of excess facilities, radioactive waste, spent nuclear fuel, and other materials resulting from five decades of nuclear weapons development and production and Government-sponsored nuclear energy research.

To date, EM has completed cleanup activities at 91 sites in 30 states and Puerto Rico, and is responsible for cleaning up the remaining 16 sites in 11 states—some of the most challenging sites in the cleanup portfolio.

The Budget continues funding of $150 million to address specific high-risk contaminated excess facilities at the Y-12 National Security Complex and the

Lawrence Livermore National Laboratory.

The Budget includes $1.4 billion for the Office of River Protection at the Hanford Site, for continued work at the Hanford Tank Farms and to make progress on the Waste Treatment and Immobilization Plant. This budget will continue progress toward important cleanup required by the Consent Decree and Tri-Party Agreement to include a milestone to complete hot commissioning of the Low Activity Waste Facility by December 31, 2023. The Budget also includes $747 million to continue cleanup activities at Richland, including continued K-Area decontamination and decommissioning remediation and the K-West Basin sludge removal project. For Savannah River, the Budget provides $1.7 billion, $287 million above enacted FY 2017, to support activities at the site. This will include the Liquid Tank Waste Management Program, completing commissioning and beginning operation of the Salt Waste Processing Facility, continued construction of the Saltstone Disposal Unit #7, a start to construction of the Saltstone Disposal Units #8/9, and support for facilities that receive and store nuclear materials.

The Waste Isolation Pilot Plant (WIPP) is essential for the disposition of transuranic defense-generated waste across the DOE complex, and the Budget provides $403 million to safely continue waste emplacement at WIPP. The Budget Request will continue WIPP operations, including waste emplacements, shipments, and maintaining enhancements and improvements, and progress on critical infrastructure repair/replacement projects, including $84 million for the Safety Significant Confinement Ventilation System and $1 million for the Utility Shaft (formerly Exhaust Shaft). These steps will increase airflow in the WIPP underground for simultaneous mining and waste emplacement operations.

The Budget includes $359 million to continue cleanup projects at the Idaho site, such as the Integrated Waste Treatment Unit, and to process, characterize, and package transuranic waste for disposal at offsite facilities. It provides $409 million for Oak Ridge to continue deactivation and demolition of remaining facilities at the East Tennessee Technology Park, continue preparation of Building 2026 to support processing of the remaining U-233 material at the Oak Ridge National Laboratory, and support construction activities for the Outfall 200 Mercury Treatment Facility at the Y-12 National Security Complex.

For Portsmouth, the Budget includes $415 million, $33 million above FY 2017 enacted, to continue progress on the deactivation and decommissioning project at the Portsmouth Gaseous Diffusion Plant, safe operation of the Depleted Uranium Hexafluoride Conversion Facility, and construction activities at the On-Site Waste Disposal facility. At Paducah, the Budget includes $270 million to continue

ongoing environmental cleanup and depleted uranium hexafluoride (DUF6) conversion facility operations at the Paducah site. In addition, the FY 2019 Budget Request supports activities to continue the environmental remediation and further stabilize the gaseous diffusion plant.

Together, these investments for Environmental Management will make significant progress in fulfilling our cleanup responsibilities while also starting to address our high-risk excess facilities at NNSA sites.

Focusing Priorities on Core Missions

The Budget continues to focus the Department's energy and science programs on early-stage research and development at our National Laboratories to advance American primacy in scientific and energy research in an efficient and cost-effective manner.

Also, in line with Administration priorities, the Budget terminates the Advanced Research Projects Agency-Energy, known as ARPA-E, and the Department's Loan Programs, while maintaining necessary federal staff to oversee existing awards and loans. Termination of these programs will save over $300 million in FY 2019 alone while significantly reducing financial risk to the taxpayer moving forward.

Advancing American Energy Dominance

The Budget requests $2.1 billion for the applied energy programs. Within these offices, the FY 2019 Budget focuses resources on early-stage, cutting-edge R&D conducted by the scientists and engineers at our 17 National Laboratories who continually develop the next great innovations that can transform society and foster American economic competitiveness and then on transitioning these breakthroughs to the private marketplace.

The Budget consolidates programs focused on bringing technologies to the market in the Office of Technology Transitions, requesting a 23% increase from FY 2017. Through concerted effort and coordination with our labs, this will reduce costs to the taxpayer while at the same time providing a robust technology transfer program to transfer breakthroughs from the National Laboratories to the private sector.

Nuclear Energy

Nuclear energy provides 20 percent of our electricity baseload, and 60 percent of our carbon-free generated electricity. The Budget provides $757 million for the

Office of Nuclear Energy to continue innovating new and improved nuclear energy technologies. The budget focuses funding on early-stage research and development, such as the Nuclear Energy Enabling Technologies program, that enables the research and development of innovative and crosscutting nuclear energy technologies to resolve fundamental nuclear technology challenges.

The FY 2019 Budget includes $163 million for the Reactor Concepts Research, Development and Demonstration program. Within this total, $128 million is for early-stage R&D on advanced reactor technologies, including $54 million for a new Advanced Small Modular Reactor R&D subprogram. This new subprogram is a one-time effort to fund cost-shared early-stage design-related technical assistance and R&D, the results of which are intended to be widely applicable and employed by nuclear technology development vendors for the purpose of accelerating the development of their advanced SMR designs. The Budget also provides $15 million within Reactor Concepts for early-stage R&D and pre-conceptual design work related to Versatile Advanced Fast Test Reactor concept.

Within the Fuel Cycle Research and Development program, the Budget provides $40 million to support the development of one or more light water reactor fuel concepts with significantly enhanced accident tolerance.

Finally, the Budget for Nuclear Energy also supports robust safeguards and security funding of $136 million—a $7 million increase—for protection of our nuclear energy infrastructure and robust infrastructure investments at INL facilities.

Fossil Energy Research and Development

The Fossil Energy Research and Development (FER&D) program advances transformative science and innovative technologies which enable the reliable, efficient, affordable, and environmentally sound use of fossil fuels. Fossil energy sources currently constitute over 81 percent of the country's total energy use and are critical for the nation's security, economic prosperity, and growth. The FY 2019 Budget focuses $502 million on cutting-edge fossil energy research and development to secure energy dominance, further our energy security, advance strong domestic energy production, and support America's coal industry through innovative clean coal technologies.

FER&D will support early-stage research in advanced technologies, such as materials, sensors, and processes, to expand the knowledge base upon which industry can improve the efficiency, flexibility, and resilience of the existing fleet of coal fired power plants. The request also focuses funding on early-stage research that enables the next generation of high efficiency and low emission coal fired power plants that can directly compete with other sources of electricity in the market and provide low cost reliable power 24/7.

Funding is also provided to support competitive awards with industry, National Laboratories and academia focused on innovative early-stage R&D to improve the reliability, availability, efficiency, and environmental performance of advanced fossil-based power systems. For example, the Advanced Energy Systems subprogram will focus on the following six activities: 1) Advanced Combustion/Gasification Systems, 2) Advanced Turbines, 3) Solid Oxide Fuel Cells, 4) Advanced Sensors and Controls, 5) Power Generation Efficiency, and 6) Advanced Energy Materials. While the primary focus is on coal-based power systems, improvements to these technologies will result in spillover benefits that can reduce the cost of converting other carbon-based fuels, such as natural gas, biomass, or petroleum coke into power and other useful products in an environmentally-sound manner.

Energy Efficiency and Renewable Energy

The Energy Efficiency and Renewable Energy budget funds $696 million to maintain America's leadership in transformative science and emerging energy technologies in sustainable transportation, renewable power, and energy efficiency. Knowledge generated by early-stage R&D enables U.S. industries, businesses and entrepreneurs to develop and deploy innovative energy technologies and gives them the competitive edge needed to excel in the rapidly changing global energy economy.

Energy storage is an important area of focus, and the Request includes $36 million for battery R&D as well as $90 million for a new "Beyond Batteries" R&D initiative. As part of grid modernization efforts, "Beyond Batteries" considers energy storage holistically, and focuses on advances in controllable loads, hybrid systems, and new approaches to energy storage, which are essential to increasing the reliability and resiliency of our energy systems.

Advances in these areas, as well as in battery technologies, will allow for loads to be combined with generation from all sources to optimize use of existing assets to provide grid services, and increase grid reliability. The FY 2019 also invests in advanced combustion engines, and new science and technology for developing

biofuels. The Budget funds research into the underpinnings of future generations of solar photovoltaic technology, into the design and manufacturing of low-specific power rotors for tall wind applications, and on wind energy grid integration and infrastructure challenges.

The Budget also funds early-stage R&D for advanced manufacturing processes and materials technologies. These efforts, combined with the research that leverages the unique high-performance computing assets in the National Laboratories, can drive the breakthroughs that will promote economic growth and manufacturing jobs in the United States.

Leading World-Class Scientific Research

The Department of Energy is the Nation's largest Federal supporter of basic research in the physical sciences, and the President's FY 2019 Budget provides $5.4 billion for the Office of Science to continue and strengthen American leadership in scientific inquiry. By focusing funding on early-stage research, this Budget will ensure that the Department's National Laboratories continue to be the backbone of American science leadership by supporting cutting-edge basic research, and by building and operating the world's most advanced scientific user facilities—which will be used by over 22,000 researchers in FY 2019.

We provide $899 million for Advanced Scientific Computing Research, an increase of $252 million above the FY 2017 enacted level. This funding will continue supporting our world-class high-performance computers that make possible cutting-edge basic research, while devoting $472 million in the Office of Science to reflect the Department's plan to achieve of exascale computing by 2021. This focused effort will drive the innovations necessary for computing at exascale speeds, resulting in computing systems at unprecedented speeds at Argonne National Laboratory in 2021 and Oak Ridge National Laboratory in 2022. The FY 2019 Request also supports quantum computing R&D and core research in applied mathematics and computer science, and high-performance computer simulation and modeling.

The Budget also provides $1.8 billion for Basic Energy Sciences, supporting core research activities in ultrafast chemistry and materials science and the Energy Frontier Research Centers. We will continue construction of the Linac Coherence Light Source-II at SLAC National Accelerator Laboratory and the Advanced Photon Source Upgrade at the Argonne National Laboratory, and initiate the Advanced Light Source Upgrade project at the Lawrence Berkeley National Laboratory, and the

Linac Coherence Light Source-II High Energy project at SLAC. The operations of the light sources across the DOE science complex and supporting research across the Nation will ensure our continued world leadership in light sources and the science they make possible.

The Budget also provides $770 million for High Energy Physics, including $113 million for construction of the Long Baseline Neutrino Facility and Deep Underground Neutrino Experiment at Fermilab, $63 million above the enacted FY 2017 level. We will continue to fund ongoing major items of equipment projects, and initiate three new projects at the Large Hadron Collider, the High Luminosity Large Hadron Collider Accelerator Project, and the High Luminosity ATLAS and CMS detector upgrade projects. By supporting the highest priority activities and projects identified by the U.S. high energy physics community, this program will continue cutting-edge pursuit to understand how the universe works at its most fundamental level.

The Budget for the Office of Science provides $340 million for Fusion Energy Sciences, including $265 million for domestic research and fusion facilities and $75 million for the ITER project. For Nuclear Physics, the budget provides $600 million to discover, explore, and understand nuclear matter, including $75 million for continued construction of the Facility for Rare Isotope Beams and operations of facilities, including the newly-upgraded Continuous Electron Beam Accelerator Facility. For Biological and Environmental Research, the Budget includes $500 million to support foundational genomic sciences, including the Bioenergy Research Centers and to focus on increasing the sensitivity and reducing the uncertainty of earth and environmental systems predictions.

Strategic Petroleum Reserve

In addition to our nuclear security responsibilities, the Department of Energy ensures the Nation's energy security. The Strategic Petroleum Reserve (SPR), one component of that effort, protects the U.S. economy from disruptions in critical petroleum supplies and meets the U.S. obligations under the International Energy Program. The Budget includes $175.1 million, $47.5 million below the FY 2017 enacted level, to support the Reserve's operational readiness and drawdown capabilities. The Request also includes a drawdown and sale of up to 1 million barrels of crude oil from the SPR to provide funding for Congressionally-mandated crude oil sales and emergency drawdown operations.

The Budget continues the sale of SPR oil for the Energy Security and Infrastructure Modernization Fund authorized by the Bipartisan Budget Act of 2015 to support an effective modernization program for the SPR.

Finally, as the Northeast Gasoline Supply Reserve (NGSR) is operationally ineffective and not cost-efficient as a regional product reserve, the President's Budget proposes to liquidate the NGSR and sell its one million barrels of refined petroleum product in FY 2019, resulting in an estimated $77 million in receipts.

Power Marketing Administrations

Finally, the Budget includes $77 million for the Power Marketing Administrations (PMAs). The Budget proposes the sale of the transmission assets of the Western Area Power Administration (WAPA), the Bonneville Power Administration (BPA), and the Southwestern Power Administration (SWPA) and to reform the laws governing how the PMAs establish power rates to require the consideration of market based incentives, including whether rates are just and reasonable. The Budget also proposes to repeal the $3.25 billion borrowing authority for WAPA authorized by the American Recovery and Reinvestment Act of 2009.

Conclusion

In conclusion, I reaffirm my commitment to ensure that the Department of Energy, along with its national laboratories, will continue to support the world's best enterprise of scientists and engineers who create innovations to drive American prosperity, security and competitiveness. The President's FY 2019 Budget Request for the Department of Energy positions us to take up that challenge and delivers on the high-priority investments I proposed to you last year.

As we move forward over the coming weeks and months, I look forward to working with you and your colleagues in Congress on the specific programs mentioned in this testimony and throughout the Department. Congress has an important role in the path forward on spending decisions for the taxpayer, and I will, in turn, ensure DOE is run efficiently, effectively, and we accomplish our mission driven goals. Thank you, and I look forward to answering your questions.

Chairman SMITH. Thank you, Mr. Secretary. And I'll recognize myself for questions.

My first question is this, that the Department of Energy is known for its development of technology from hydraulic fracturing to supercomputing to better batteries for electric cars. And, Mr. Secretary, I'm just wondering how important you think it is for technologies to try to be used to meet the challenge, for example, of climate change.

Secretary PERRY. Yes, sir. Obviously, living in a world that has an environment that's pleasant, that's safe is important. We were able to do that in the State of Texas while I was the Governor. It's one of the things that I'm really proud of. I mentioned that. You mentioned it in your remarks as well during that 14-year period of time we drove down nitrogen oxide levels by over 60 percent, SOx by over 50 percent, carbon dioxide by almost 20 percent, while we grew more than any other state in the nation. We added seven million people to the population roles of the State of Texas during that period of time, and I tell people, I say you know that means. That's a lot of pickup trucks. So——

Chairman SMITH. That's true.

Secretary PERRY. And so that's nonpoint source pollution. You're—conventional wisdom was, well, you're growing a lot of vehicles on the road. You got all that petrochemical stuff going on down there, ozone, and so you've got to be playing heck with your environment, but we didn't. And we didn't because we put thoughtful processes and we used technology and we allowed technology, and that's where the national labs are going to continue to play a very important role to make sure that our, you know—not only is it about job creation but it's about addressing issues that are important like our—the environment that we live in and making sure that the emissions—you know, CCU down in Houston where we built now the biggest, largest—I think at this time still—carbon capture utilization plant in the world. We're sequestering I think over 95 percent—or not sequestering, we're capturing over 95 percent of the carbon and then shipping it over using it for secondary recovery.

These are the types of science that come out of the national labs that we can implement and see the type of results that I think you and the Members of this Committee are looking for.

Chairman SMITH. Thank you. Mr. Secretary, also the Department is known for its development and research into fusion energy, which might well be the solution to a lot of our energy needs in the future. There's an international effort called ITER, which may or may not be receiving the funding that they would like. And I'm just wondering how important you think that ITER effort is and how important it is that the Department of Energy continue to fund the development of fusion energy.

Secretary PERRY. Yes. Mr. Chairman, I think fusion has the potential to really change the world, so taking that position but also looking at—from time to time, one of the things that I ran into over the last 18 months, as I became intimately knowledgeable about what the Department of Energy does, from time to time, we get involved with some areas where the expenditures are off the charts, and, you know, I'm not going to sit here and try to micro-analyze

this and say it's all been because of bad management or what have you, but I mean the billions of dollars that we spend on the MOX facility out in South Carolina and some of our environmental management cleanups, I mean, there have been some, you know, I think questionable—historically questionable expenditures of dollars. ITER is one of those. And it was poorly managed. I mean, I don't think anybody argues that there was some management decisions made at that big consortium that's over in France.

Now, with all of that said, I think the previous Administration and this Administration both stepped back from that and said wait a minute, let's take a look at this and make sure that the dollars that we're going to be expending there, we're getting a good return on our investment. And that's exactly what we're doing, Mr. Chairman. We think that this—and they have new management. I've sat down with Mr. Bigot and we've discussed and I'm getting comfortable that the management of ITER is indeed back on track. They're headed in the right direction.

Chairman SMITH. Okay.

Secretary PERRY. So, you know, I'm—one of the things I learned as an appropriator back in—as a boy in Texas and as the Governor was that I know how the appropriations process works, and I respect it greatly.

Chairman SMITH. Okay.

Secretary PERRY. And it's the Members of this Committee and the appropriators that are going to decide about, you know—they expect me to be a good manager, and that's what I'm going to tell you is I'm going to be as transparent and hardworking person to earn your trust from a management standpoint.

Chairman SMITH. Okay.

Secretary PERRY. And if you see fit that—I'm going to try to give you the best information I can, but you see fit that projects like ITER need to be funded, we will give good oversight and we will make them be as transparent as we can and try to get us the results——

Chairman SMITH. Okay.

Secretary PERRY. —that this committee wants.

Chairman SMITH. Mr. Secretary, thank you. My time is expired.

The gentlewoman from Texas, the Ranking Member Ms. Johnson, is recognized for her questions.

Ms. JOHNSON. Thank you very much, Mr. Chairman.

Mr. Secretary, I think that—I appreciate your statement and agree with what you've said about the progress in Texas. We started from a very low ebb and we've gone a long ways, but we have a long, long ways to go.

Secretary PERRY. Yes, ma'am.

Ms. JOHNSON. I guess my focus will be on the budget because I think I heard you say that it's really up to this committee to make those budget authorization decisions, but we do have a budget before us that came over that does not necessarily I think reflect some of the things that you have spoken about, but you also said you would take on most what we give you and to do the best you can to manage it.

But how can you agree for the 70 percent cuts to the energy efficiency and renewable energy and support these cuts? Where do you

say—did you have input on this or what is your opinion on what we are facing as your budget before us, getting rid of ARPA–E and all that? Did you have any input on that, and where do you stand?

Secretary PERRY. Ms. Johnson, one of the things that I think is important to understand on the global look at the EERE and energy efficiency and that side of the house, it's important for us to recognize that some of the dollars that were expended over, let's say, the last decade were in those early-stage dollars—appropriately from my perspective I might add—in some of the renewables, solar and wind.

As those have matured—it's kind of like when I sent my kids off to college, that was a costly process. And then they graduated and went on and went to work and I didn't expend those dollars because they had basically matured. Some of the things that you've seen in that side of this budget, that's the reason that it's occurred and you've seen the reduction in spending because those have made maturations.

And I don't think it's any indication at all that there's a lack of support for our renewables at the Department. I mean, you know this, having lived in Dallas in Texas, no State developed more wind energy in the nation while I was the Governor than Texas. Matter of fact, we created more wind than all but five countries. So the commitment to the renewables is still there. I think as we—I don't like to use the term ebb and flow, but as we transition away from forms of energy that are maturing into others, you'll see these changes in the budget.

Now, with that said, I think, you know, we can always disagree that the total amount of money is the right amount of money. That—again, I respect this process greatly. You and I might not agree upon a total dollar amount in a particular line item.

Ms. JOHNSON. Thank you. My time is expired.

Chairman SMITH. Thank you, Ms. Johnson.

The gentleman from Oklahoma, Mr. Lucas, is recognized.

Mr. LUCAS. Thank you, Mr. Chairman.

And I do note the observation of the number of, you know, Texans on important leadership positions on this committee. And of course the Secretary, having been the Governor, we in Oklahoma sometimes are viewed as the buffer zone or the catalyst or whatever, but you can always tell a good Texan. If you refer to it as the Republic of Texas, they invariably smile, so you know they're a real Texan.

That said, Mr. Secretary, I was pleased to see in the fiscal year 2019 budget a refocus on the biological and environmental research programs on genomic science, particularly the funding included for four recently renewed bioenergy research centers. These centers provide fundamental science for better understanding of plant and micro biosystems, allowing DOE researchers to work with industry to create the next generation of transformative bioenergy resources and bio-based products. Can you update the Committee on the research goals for the bio research centers?

Secretary PERRY. Yes, sir. And, Mr. Chairman, if I may, I'd like to introduce Paul Dabbar. He's our Assistant Secretary for Science——

Chairman SMITH. Okay.

Secretary PERRY. —and his shop, that's where that is. And, Mr. Lucas, if I may——

Mr. LUCAS. Please.

Secretary PERRY. —and just to remind you, we were a Republic once.

Mr. LUCAS. Never a doubt in my mind.

Secretary PERRY. So, Paul Dabbar.

Mr. DABBAR. And as an Oklahoman, as the wing man here to the Air Force officer, I thank you for this question.

The bioenergy area in the area of BER is very important. And actually, we're focusing more resources on that. There's a few areas that we find particularly interesting. As you know, the DOE labs were at the forefront, along with NIH, in terms of gene editing, gene sequencing. A lot of people don't know that. And, as a result, we have a lot of history and a lot of future ahead of us.

The first area that we're working on is in the area of precision medicine. This is tailoring specific therapeutic treatments to the individual genomics for a particular person. This is a very exciting area in the area of biotech and the genomics area for the Department that we work on with other universities and the National Institutes of Health, which could have a monumental shift in where health goes in this country.

Secondly, we continue to do a lot of work in the area of bioenergy, looking at different types of plants that can be used in a more efficient manner, more efficient on the land, more efficient with water to look at applications associated with that.

Thirdly, we do a lot also in another area of plant genomics, which could be used for biotech drug manufacturing. Taking various genomic sequences that certain plants have and being able to use those to engineer a manufacturing of biotech drugs outside of having to have to grow the individual plants, it's a very important area that Lawrence Berkeley in particular but a number of other of our labs that are leadership in, and so we're very excited about those opportunities.

Mr. LUCAS. Governor, just one final thought here in the time that I have remaining just from a geographical reference. I'm fond of the Republic of Texas. I live 50 miles down the river from Canadians, so you know my geographic location.

Secretary PERRY. I know exactly where you are.

Mr. LUCAS. And with that, I would like to just reinforce comments made by my colleagues about the importance I think of ARPA–E——

Secretary PERRY. Yes, sir.

Mr. LUCAS. —how that leverages your technology abilities within the agency, with private industry, and the potential to do great things I think exists in ARPA–E.

Mr. LUCAS. And with that, Mr. Chairman, I'll yield back.

Chairman SMITH. Thank you, Mr. Lucas.

And the gentleman from California, Mr. Bera, is recognized.

Mr. BERA. You caught me off-guard there.

You know, thank you for appearing here, Mr. Secretary. You know, I know we're in conversations with Saudi Arabia right now about their pursuit of nuclear energy and nuclear reactors. You know, obviously this would be a big deal. They're planning on

spending about $80 billion to build 16 nuclear reactors over the next 25 years. And, you know, there obviously is some concern as we're negotiating the 123 agreement. The Obama Administration was never able to quite get that agreement completed because of concern over the Saudis potentially using those reactors for nuclear enrichment. You know, if you could give us an update on how those negotiations are going.

You know, in a recent 60 Minutes interview, the Saudi Crown Prince suggested that if Iran were to pursue nuclear weapons, they certainly would be within their rights to pursue nuclear weapons as well. And with yesterday's pulling out of the Iran nuclear deal, certainly there's the potential of that deal collapsing and the Iranians going back to their pursuit of nuclear ambitions. There's real concern in a bipartisan way in this body, in a bicameral way, that we may enter into a 123 agreement that actually does allow the Saudis to pursue nuclear enrichment, and I'd be curious to get your perspective on that.

Secretary PERRY. Yes, Mr. Bera, absolutely. And I think I share—along with I would suggest every one of the people on this committee—your concerns about an increase in proliferation of nuclear materials in the world. And that goes right to the point that we've tried to make with the Saudi Crown Prince in our conversations with him and with his team that not only will it send a powerful message if they go into an acceptable 123 with additional protocols but that we—that they do that because if they don't, the message that's sent—if the Chinese or the Russians, which don't require any of that, not only does it send the message—I think the wrong message by the Kingdom of Saudi Arabia but it also sends the message to the United States that we're no longer the leader in the world when it comes to civil nuclear power.

Westinghouse, best reactor builder in the world——

Mr. BERA. Right.

Secretary PERRY. —you know, they've had their challenges from a business standpoint, but it wasn't because they're not really good at building reactors. It's because they got involved in the construction side of it, which is not their expertise. That's been straightened out. They have been, you know, working their way, but the reactor side of this is very important, and that is the second point that we tried to really drive home to the Crown Prince was that if you want the best reactors in the world, you have to come to the United States and you have to use Westinghouse.

So you have to be seen, you know, what the Kingdom is going to decide when it comes to who's going to be allowed to build those, but I think for us as Americans, for us that truly believe in nonproliferation, that that is a powerful place for us to be and the goal that we need to go into every arrangement, that if the Kingdom of Saudi Arabia does not sign a 123 with us with additional protocols, the message will be clear to the rest of the world that the Kingdom is not as concerned about being leaders when it comes to this issue, and they'll be losing a great opportunity to stand up and say the Kingdom of Saudi Arabia is a serious country when it comes to nonproliferation and to the development of nuclear power in the Middle East.

Mr. BERA. Great. Well, know that you've got bipartisan support——

Secretary PERRY. Yes, sir. Thank you.

Mr. BERA. —with that 123 agreement.

Chairman SMITH. Okay. Thank you, Mr. Bera.

The gentleman from California, Mr. Rohrabacher, is recognized.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

And, Mr. Secretary, you have every right to be proud that America is now energy-independent. This didn't just happen. The fact is is that there have been political elements and disagreements that perhaps would have stopped fracking in its place, which is the new system that's given us so much energy and given us natural gas, which has permitted that level of CO_2 to go down, as you mentioned.

Let me just note that, as you take over your new responsibilities here, one of the most important responsibilities is to say no when things are bad, don't really—aren't as good as other alternatives or more expensive. And I would hope that, as you get into your job, that you take that part of your job very seriously.

Quite frankly, building any new nuclear power plants based on the current technology is I believe not only a waste but a danger to the American people and the people of the world. The old-style nuclear reactors, for example, the reactors you're talking about that you want to sell to Saudi Arabia, do they produce plutonium?

Secretary PERRY. Yes, sir.

Mr. ROHRABACHER. They do. Okay. Why should we—when we are capable—we have the capabilities now of building a new generation of nuclear power that will not have plutonium left over, that can't melt down, that in fact will use the nuclear waste from the current generation as fuel and eat it up rather than having to have it here threatening us, I would hope that you take a very close look at that.

And instead of just giving your support to ongoing projects like ITER, which has not seen any progress towards giving us a real energy source but sure eats up a lot of money, and so I'd hope as you move forward in this job—and I know you take it seriously. I think Texans have a lot to be proud of what you did down in Texas. So I will refrain from talking about all the wind that Texas produces. We think—that's enough. I won't go down that road.

But let me just ask you this, Mr. Secretary. Mr. Shimkus of Illinois has a piece of legislation aimed at trying to offer us at least moving forward with some kind of plan that will make it safer—right now, the nuclear energy that's being stored throughout the country, including San Onofre, California is enormously expensive——

Secretary PERRY. Yes, sir.

Mr. ROHRABACHER. —and I'm not sure that it's safe to have all the nuclear energy stored like that. Shimkus would reopen the Yucca Mountain debate. Do we have a position on that?

Secretary PERRY. Yes, sir. From the standpoint of there are 38 States that have nuclear materials stored in less-than-satisfactory places, one of them being San Onofre. And I've got great concern about San Onofre being in the circle of fire. It's exactly the same geological area that Fukushima was in.

Mr. ROHRABACHER. Right. Correct.

Secretary PERRY. And so the idea that you could have a major earthquake and with that a tragic event, that whole inland empire, you take that off of the economic—and it could be disastrous to our country——

Mr. ROHRABACHER. Let me invite you to San Onofre and we could go through that together.

Secretary PERRY. Yes, sir.

Mr. ROHRABACHER. You haven't been there?

Secretary PERRY. I've driven by it a number of times but have never been in it, so I——

Mr. ROHRABACHER. That would be a good thing to do. And I appreciate your leadership. And, again, leadership quite often means saying no——

Secretary PERRY. Yes, sir.

Mr. ROHRABACHER. —and that's the hardest part of a job here in Washington is saying no to people who want money.

Secretary PERRY. Yes, sir.

Mr. ROHRABACHER. Thank you.

Chairman SMITH. Thank you, Mr. Rohrabacher.

The gentlewoman from Nevada, Ms. Rosen, is recognized.

Ms. ROSEN. Well, thank you, Mr. Chairman, Ranking Member, and Secretary Perry for being here today.

I want to also talk a little bit about Yucca Mountain because, for decades, Nevadans have been fighting our State being a dumping ground for the nation's nuclear waste. Yucca Mountain is actually seismically active as well. But besides that, what I want to do is emphasize how Yucca Mountain is also a threat to our national security because the site is located on DOE's national security site, which, as you know, provides DOE and other government agencies unique high-hazard testing environments.

Yucca Mountain is also adjacent to the Nevada Test and Training Range, which is the largest air and ground military training space in the contiguous United States, and it is home to 75 percent of all the stateside Air Force live munitions.

So according to Air Force Secretary Heather Wilson, there is no transportation route—I repeat that—no transportation route across the NTTR that would not impact testing and training even around—outside the range's boundary that might create encroachment issues.

So, Mr. Chairman, I ask unanimous consent to put—provide a map about Nevada sites into the record, please.

Chairman SMITH. Without objection, it'll be made a part of the record.

[The information follows:]

Potential Nevada Rail Corridors to Yucca Mountain

Ms. ROSEN. Thank you.

So, Mr. Perry, Secretary Perry, to your knowledge, has the DOE worked with the Department of Defense to address these concerns, the concerns of Air Force Secretary Heather Wilson on the Yucca Mountain project?

Secretary PERRY. Ms. Rosen, we are in pretty constant contact with our colleagues over at DOD in a host of different areas, that certainly be one of them. I think the important aspect of this issue from a DOE standpoint and the Secretary of Energy standpoint is that I have a requirement of law to take this licensing process forward. In this budget that we're talking about I think there's $120 million, 110 of which is on the licensing side and going forward with NERC to get an answer on the licensing side.

So, you know, the debate about Yucca, whether it should be opened, it shouldn't be opened, it's been ongoing for a long time, I think $15 billion worth of time. But my responsibility here is not to tell you whether I'm for Yucca or against Yucca from the standpoint of it being a permanent facility. It's to follow the law, and the law says that DOE will go forward with the licensing side of it.

Ms. ROSEN. Might I suggest, Secretary Perry, that you work in collaboration with our Department of Defense to secure our Nevada Test and Training Range and secure our live munitions.

And I'd like to reiterate what happens on the Nevada test site as far as testing of hazardous material, Yucca Mountain sits right there. It's also 60 miles from rare earth mines in California and not too much further on from the San Andreas Fault. So we need to talk about those things. You can't exist in a vacuum. I would urge you to work with the Department of Defense on discussing these highly important issues of national security.

Secretary PERRY. We'll continue to do that with the DOD.

Ms. ROSEN. Thank you. I yield back.

Chairman SMITH. Thank you, Ms. Rosen.

The gentleman from Illinois, Mr. Hultgren, is recognized for questions.

Mr. HULTGREN. Thank you, Mr. Chairman.

Thank you, Mr. Secretary, grateful for your work and the team that you've put together. I want to commend you for the work you've been doing at DOE, and I keep hearing nothing but good things when I'm out talking to people back home in Illinois at Fermilab and Argonne, grateful again for your visit and Mr. Dabbar's visit. I had a great time with him there touring and also excited that a group of the Committee are going to be going to visit Argonne and Fermi this weekend, so important for us to recognize the incredible value, the treasure that we have with our national labs and how important of a piece they are in this ecosystem of science, and so thank you.

I'm also going to continue to work in a bipartisan fashion. We've got a National Labs Caucus here in the House to keep telling the story of the great work that's happening throughout our lab system, and grateful again for your commitment and support there.

I've heard discussions about the National Science and Technology Council establishing a Science Infrastructure Subcommittee. This is something this committee has worked on with a number of bills, including my legislation to authorize construction of the Long-Base-

line Neutrino Facility, as well as upgrades to APS at Argonne and the Spallation Neutron Source at Oak Ridge. What are the current plans of this subcommittee? What are its goals, and will DOE and Office of Science have a prominent role? I believe our DOE user facilities are truly the crown jewel of our research ecosystem, and I hope we continue to work with you to see these facilities and researchers supported.

Secretary PERRY. Mr. Chairman, for the best edification of the Committee, I'd like to ask Paul again. This is right in his shop, and again——

Mr. HULTGREN. That's perfect.

Secretary PERRY. —he can succinctly address this.

Mr. HULTGREN. Great. Thanks.

Mr. DABBAR. Congressman, thank you, and I look forward to seeing you and many other Members here at Argonne on Friday.

I sit as a Co-Chair with Under Secretary Copan from NIST from Commerce on that particular committee that you asked about. We are—we have a number of subcommittees on different sorts of research and not just energy but many other things across the whole of the federal government in terms of the infrastructure, much of which is based on labs, much of which also has topics around lab-to-market topics that obviously both us and Under Secretary Copan are part of. And so there's a number of different committees. I co-chair that, and items such as infrastructure buildout and national labs such as at Fermi and Argonne are an important part.

Mr. HULTGREN. Great. Thanks, Mr. Dabbar.

Mr. Secretary, I commend your work at the Department trying to find ways to get bureaucratic barriers out of the way so that the private sector can be nimble bringing new ideas to the market. This House has passed legislation a number of times that would give lab directors the signature authority for technology transfer agreements and other cooperative research projects under $1 million. I had a brief discussion with the Under Secretary Dabbar about this provision, and I believe it to be in line with the Administration's goals and in the Department. I wonder, would this provision concern you, and is this something we can work with you in trying to move forward on?

Secretary PERRY. No, sir, it does not concern me.

Mr. HULTGREN. Great. Again, thank you. We want to work with you. We're grateful for your commitment to all of the work in the Energy Department but I especially have a great passion for our labs and want to thank you for your commitment there as well.

With that, I'll yield back the balance of my time.

Secretary PERRY. We share that passion, sir.

Mr. HULTGREN. Thank you. Thank you, Secretary.

Chairman SMITH. Thank you, Mr. Hultgren.

And the gentleman from Pennsylvania, Mr. Lamb, is recognized.

Mr. LAMB. Good morning, Mr. Secretary. I was encouraged to hear you say in the opening that your greatest concern is the reliability and resiliency of the electrical grid. And I am very concerned about the challenges that the nuclear plants in my State of Pennsylvania now face. We have thousands of hardworking men and women who work at these plants every day, and they work

hard to ensure that we have the reliable source of energy, the carbon-free source of energy provided by these nuclear plants.

You also noted the concerns of cyber attacks and cyber threats to the grid, and I know that some of these nuclear plants like Beaver Valley, which is close to where I live, are almost completely independent of the internet. I mean, the control room is amazing. It's a large analog operation that would be resilient and reliable in the event of a cyber attack on the rest of our grid.

So I know that your agency is considering the 202(c) request from FirstEnergy related to baseload capacity. I'm not going to ask you to weigh in on that this morning. I saw your comments that 202(c) may not be the way we decide is the most appropriate or the most efficient way to address this, and you seem to believe that there are other options for the nuclear plants especially besides 202(c). So I was hoping you could fill us in. What do you see as other options on this issue?

Secretary PERRY. Well, I'm looking for a solution. I'm looking for results. I'm—you know, the process kind of wears me out from time to time. And my point is the 202(c) is an economic issue. I mean, that's approaching this from an economic standpoint. And I think it's really important for us as a country to look at this for what you and I think—understand it to really be about, and it's about the national security of our country, of keeping our plants—all of them—online, being able to deliver energy no matter whether it's a natural disaster that we might see from a polar vortex or it's something more nefarious as a cyber attack from a terrorist state or some entity with bad intent for the United States. So we're looking at a number of ways to approach this. I know that the Defense Production Act is one of those ways to address that, that we're looking at very closely as well.

So having resiliency and reliability in our grid is as important to our national security as anything that I can think of. And making sure that the plants that we have today supported reliably with the fuel, and obviously nuclear is one of those, and there are coal plants out there that fit into that.

I might just make the statement of fact that by 2040 the world will still be relying upon 77 percent of fossil fuels of driving that energy that's being produced.

Mr. LAMB. And I've seen that as well, Mr. Secretary, so I just want you to know that you have a partner here in trying to find other solutions on this issue. I will be happy to help in any way, and my staff will certainly reach out.

Along that line, we have seen States pass some legislation to try to address this issue and to try to correct some of the market failures, especially for nuclear plants. Do you support the efforts of States like New Jersey and Illinois and New York that have taken on this issue and tried to develop their own solutions to correct some of these failures?

Secretary PERRY. Yes, well, I wrote a book about the Tenth Amendment, so I—it would be pretty hard-pressed for me not to say that I don't believe that States have a very important role.

I think there is another issue that's a side issue but directly to this. Do States have the right to block a pipeline across their State that will have a national security implication or an economic impli-

cation on individuals? And that's a whole other issue, but it's one I hope you and I can continue to have a conversation on. That—the fight there will be the State's sovereign ability to make a decision versus the national security of this country.

Mr. LAMB. Thank you.

Secretary PERRY. Yes, sir.

Chairman SMITH. Thank you, Mr. Lamb.

The gentleman from Texas, Mr. Weber, is recognized.

Mr. WEBER. Thank you.

Welcome, Mr. Secretary.

Secretary PERRY. Thank you. Howdy.

Mr. WEBER. It's great to see you.

Secretary PERRY. Yes, sir. Thank you.

Mr. WEBER. We didn't tell these other States that Texas has our own grid primarily.

Secretary PERRY. They probably already know that.

Mr. WEBER. Yes, I'm just saying.

The gentleman from California, Mr. Rohrabacher, will be——

Secretary PERRY. And we'd like to keep it that way.

Mr. WEBER. Well, amen. Let's talk about the Tenth Amendment. And your book is on sale, right, about the Tenth Amendment?

Secretary PERRY. Very much on sale.

Mr. WEBER. I'm just saying.

I'm pleased to see the funding requested in the fiscal year 2019 budget includes request for what's in my bill, a versatile neutron source—Dana, you'll like this—the next round of nuclear reactors. My act is called the *Nuclear Energy Innovation Capabilities Act*. It's clear that we need progress on this facility. This is where we can build the next round of reactors to move more quickly if we're going to meet the needs of the advanced reactor community.

So, Secretary Perry, I guess I don't know how much you've looked at that bill that we've got coming down the line. You know we're getting outstripped by Russia in nuclear innovation, and that's totally unacceptable. That's totally unacceptable. So I'd like for you to think about it, commit if you would to the funding of the versatile test reactor, and make that a top priority in energy R&D. It looks like maybe Mr. Dabbar——

Secretary PERRY. Yes.

Mr. WEBER. —has got some experience on that or no?

Secretary PERRY. Paul, you want to just—he pitched you a soft one.

Mr. DABBAR. I—yes. Yes, sir, having run a reactor in my younger days. This is an important area. We've asked for $148 million as part of the 2019 budget request around advanced reactors, in addition, SMR reactors as another area that we're very much focused on. So this is an area that is important, and I'd also like to point out for Congressman Beyer in Virginia, we just also—that big CEBAF nuclear physics facility that we just inaugurated this last week that had a ribbon-cutting on shows another area of leadership in the nuclear area that we do for the country.

Secretary PERRY. Yes, Mr. Weber, I think it's—and this is exactly down the line that Mr. Rohrabacher was making reference to from the standpoint of the old way of building civil nuclear reactors, it would be like kind of the old way they built cars. I mean, the tech-

nology has changed, and we need to take advantage of the technology. We need to be a part of the technology.

We need to be—and I might—let me just finish it by saying the work that we're doing at Idaho National Lab is right along this line with the advanced reactors, and the funding of the national labs directly affects your point here.

Mr. WEBER. Sure.

Secretary PERRY. And INL is one of the lead labs that's dealing with advanced nuclear reactors.

Mr. WEBER. Right. And back to Mr. Rohrabacher's point, we're going to need an advanced fuel, so there's going to have to be R&D on fuel for this advanced reactor, which part of the discussion has been. We can take some of that old fuel, whether it's military grade or whatever kind of fuel it is. We can actually investigate and do the research on how to use that fuel in some of these advanced reactors and maybe do away with some of the storage. As you know, South Texas Nuclear Project when I was a State Rep is—was in my district, and we watched them change fuel rods, so it's very, very important. You mentioned the 38 States I think that stored onsite. That's just not sustainable. So we would also ask you all to commit to not only the advanced nuclear reactors in the versatile neutron source but also to research on the fuel for that next round. Are you all able to do that?

Secretary PERRY. Yes. Well, we have some work going on now with the high-assay——

Mr. WEBER. Right.

Secretary PERRY. —low-enriched uranium that I think fits the description of what you're talking about right there.

Mr. WEBER. Sure. Well, I appreciate that. And, Mr. Dabbar, you're going to be with us at the labs this weekend, I believe.

Mr. DABBAR. Yes, sir. I look forward to being there with you.

Mr. WEBER. Okay. Well, bring the Secretary with you. I'm just saying, but thank you, Mr. Secretary.

Mr. Chairman, I yield back.

Chairman SMITH. Okay. Thank you, Mr. Weber.

The gentlewoman from Oregon, Ms. Bonamici, is recognized for questions.

Ms. BONAMICI. Thank you, Mr. Chairman, and thank you, Mr. Secretary, for being here.

Our nation has some of the best scientists, researchers, programmers, and engineers in the world, but without strong investments in research and development, we fall behind. We risk falling behind our international competitors. This proposed budget takes us in the wrong direction, and I want to align myself with my colleagues who have objected to eliminating ARPA–E.

And I'm glad to see that the Administration is supporting increased advanced scientific computing research, but foreign governments like China are much more aggressive with their investment in exascale computing. We're falling behind there. This could have serious implications for our U.S. leadership for national security, economic competitiveness, and innovation.

I'm disappointed to see that the Department of Energy's budget proposal would make significant cuts to the development of clean energy technologies, including water power. In my State of Oregon,

Oregon State University is a global leader in marine renewable energy research and development. The Pacific Marine Energy Center relies on federal investment from the Office of Energy Efficiency and Renewable Energy to establish the nation's fully energetic on-grid wave energy test facility off the Oregon coast. This facility will be able to test wave energy converting—converters that harness energy of ocean waves and currents and turn it into electricity. Hydropower has been—has tremendous potential to become a major source of electricity for the United States and the world, and other countries are ahead of us here.

Mr. Secretary, your budget proposal cuts funding for hydropower research and development by more than 57 percent, so do you agree that this country should be reducing our dependence on fossil fuels, and if so, why is the Department pursuing such severe cuts for federal energy research investment?

Secretary PERRY. Yes, ma'am. Let me just say in a global way we do support the renewables. You know, we can argue about the level of funding, which is what the appropriations process is all about, but we are continuing to fund the program. And I think it's—is it Oregon State? I'm——

Ms. BONAMICI. Oregon State University has the facility.

Secretary PERRY. Yes, ma'am. Yes. That's what I was thinking. It is Oregon State that is—and we're still funding that, so the support is still there certainly. You know, the—again, the level of funding we can discuss, but——

Ms. BONAMICI. Well, Mr. Secretary, with a 57 percent cut, that's serious, and as someone whose responsibility it is to advise the President, I hope that you will advise the President that this is a good investment to invest in renewable energy.

And also, Mr. Secretary, I was glad to see you mention the importance of the labs. The National Energy Technology Laboratory is in Albany, Oregon, and they're working to make our energy systems more efficient. They're developing new sensors and controls for power plants in our grid, designing materials that can be used in extreme high-temperature environments, and advancing carbon capture technologies to reduce emissions. These efforts should be a model for the energy industry nationwide, but the fiscal year budget justification discussed a phased approach to consolidate the NETL location. What is the status? It's unclear from your proposal. Does the Department intend to close the NETL Albany location, and could you please provide us with an update on the possible consolidation of the NETL sites?

Secretary PERRY. So to answer your question directly, there are no NETL reorganization plans being discussed that would result in the closure of your facility out in Albany, Oregon. They are still continuing to focus on advanced power applications and material performance research, geospatial data analysis, so in a nutshell, no.

Ms. BONAMICI. I appreciate that. Thank you.

Secretary PERRY. Yes, ma'am.

Ms. BONAMICI. I yield back, Mr. Chairman.

Chairman SMITH. Thank you, Ms. Bonamici.

And the gentleman from Florida, Mr. Posey, is recognized.

Mr. POSEY. Thank you, Mr. Chairman.

Mr. Secretary, thank you for being here today.

Based on the testimonies that we've heard in committee, I'm concerned about the uncertainty and the way we assess the greenhouse gas emissions associated with blending ethanol in our fuel supplies. As you know, being accurate in these estimates depends on integrating the lifecycle effects of land-use changes in the growing of corn and other feedstocks for ethanol production. We should add these emission impacts into the estimate to get a full and accurate picture.

Looking at the full lifecycle, some scientists contend that the greenhouse gas implications of land-use changes outweigh any savings in burning ethanol compared to fossil fuels. A University of Michigan study was particularly enlightening about the lifecycle aspects of ethanol, and I ask, Mr. Chairman, unanimous consent to enter into the record a study conducted by Professor John DeCicco.

Chairman SMITH. Without objection, that will be made a part of the record.

[The information follows:]

Climatic Change (2016) 138:667–680
DOI 10.1007/s10584-016-1764-4

Carbon balance effects of U.S. biofuel production and use

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Received: 5 May 2016 / Accepted: 24 July 2016 / Published online: 25 August 2016

Abstract The use of liquid biofuels has expanded over the past decade in response to policies such as the U.S. Renewable Fuel Standard (RFS) that promote their use for transportation. One rationale is the belief that biofuels are inherently carbon neutral, meaning that only production-related greenhouse gas (GHG) emissions need to be tallied when comparing them to fossil fuels. This assumption is embedded in the lifecycle analysis (LCA) modeling used to justify and administer such policies. LCA studies have often found that crop-based biofuels such as corn ethanol and biodiesel offer at least modest net GHG reductions relative to petroleum fuels. Data over the period of RFS expansion enable empirical assessment of net CO_2 emission effects. This analysis evaluates the direct carbon exchanges (both emissions and uptake) between the atmosphere and the U.S. vehicle-fuel system (motor vehicles and the physical supply chain for motor fuels) over 2005–2013. While U.S. biofuel use rose from 0.37 to 1.34 EJ/yr over this period, additional carbon uptake on cropland was enough to offset only 37 % of the biofuel-related biogenic CO_2 emissions. This result falsifies the assumption of a full offset made by LCA and other GHG accounting methods that assume biofuel carbon neutrality. Once estimates from the literature for process emissions and displacement effects including land-use change are considered, the conclusion is that U.S. biofuel use to date is associated with a net increase rather than a net decrease in CO_2 emissions.

1 Introduction

Production and consumption of biofuels, meaning biomass-based liquids such as biodiesel and ethanol, has grown steadily in the United States, from 4.2 billion gallons (0.37 EJ/yr) in 2005

Electronic supplementary material The online version of this article (doi:10.1007/s10584-016-1764-4) contains supplementary material, which is available to authorized users.

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to 14.6 billion gallons (1.34 EJ/yr) in 2013 (EIA 2015; higher heating value basis). By 2013 biofuels accounted for nearly 6 % of U.S. motor fuel energy consumption. The use of biofuels to displace petroleum has been driven by public policies, including subsidies but most compellingly by regulations, notably the U.S. Renewable Fuel Standard (RFS) and California Low-Carbon Fuel Standard (LCFS). Policy rationales include agribusiness income, energy security, oil depletion and greenhouse gas (GHG) mitigation (Brown and Brown 2012).

The environmental justification rests on the assumption that, as renewable alternatives to fossil fuels, biofuels are inherently carbon neutral because the CO_2 released when they are burned is derived from CO_2 uptake during feedstock growth (NRC 2011, 195). That convention is premised on globally complete carbon accounting in which biogenic emissions are not counted in energy sectors when carbon stock changes are counted in land-use sectors. This assumption has been used in cap-and-trade programs and carbon taxes as promulgated to date, which address only fossil-derived CO_2 emissions. However, errors arise when bioenergy is treated as carbon neutral in national and subnational policies, which do not impose globally coherent accounting that tracks all carbon stock changes (Searchinger et al. 2009).

The carbon neutrality assumption is also embedded in lifecycle analysis (LCA), which traditionally focused only on production-related GHG emissions within a fuel's supply chain. Some LCA models omit biogenic CO_2 emissions from the accounting, as in the U.S. Environmental Protection Agency (EPA) analysis of the RFS (EPA 2010a). Others automatically credit biogenic CO_2 emissions during their calculations, as in GREET (2011). GREET modeling finds that corn ethanol, the dominant fuel used to comply with the RFS, reduces GHG emissions by 20–50 % compared to petroleum gasoline (Wang et al. 1997; Wang et al. 2012). Such studies have justified biofuel promotion as a both a near- and long-term GHG reduction strategy (Greene 2004; Farrell et al. 2006; CARB 2010) and justify claims that the RFS has reduced GHG emissions to date (BIO 2015).

Once the significance of carbon stock changes, notably those due to indirect land-use change (ILUC), was recognized, traditional (attributional) LCA models were supplemented by economic modeling of market effects. Such consequential LCA methods are used to compute "carbon intensity" (CI) metrics for the RFS and LCFS (EPA 2010a; CARB 2010). However, their results are highly uncertain, undermining confidence in GHG reduction benefits (NRC 2011). These LCA methods now have a system boundary that spans the globe spatially and extends many years into the future temporally. Thus, although it was proposed as an objective way to compare fuels (DeCicco and Lynd 1997; Sperling and Yeh 2009; CARB 2010), LCA has become a form of scenario analysis. However, it is inferior in this regard to integrated assessment modeling (IAM), which uses a biogeochemically and economically coherent analytic framework that LCA lacks (Delucchi 2013; DeCicco 2015). Moreover, as a static framework, it fails to reflect the stock-and-flow dynamics that are fundamental to bioenergy systems (DeCicco 2013; Haberl 2013). Indeed, policy applications of LCA raise serious questions regarding the limitations of the method (Plevin et al. 2014; McManus et al. 2015).

Given such concerns, it is useful to analyze the situation by a method other than LCA. One can empirically examine the direct carbon exchanges associated with the displacement of petroleum fuels by biofuels since the RFS was passed in 2005, a period for which commercial-scale data are available. Here, *direct* exchanges refer to carbon flows, including CO_2 uptake and CO_2 emissions as well as movements of material carbon, between a vehicle-fuel system and the atmosphere, other parts of the biosphere (notably the food system where biomass used to make biofuels would otherwise be consumed) and the geosphere. *Material* carbon refers to carbon bound in organic materials (whether recently fixed through photosynthesis or of fossil

origin) as opposed to CO_2. The system to be analyzed includes motor vehicles using fuels regulated by the RFS and the associated fuel supply chains. The latter include farms and oil wells, biorefineries and petroleum refineries, operations that transport feedstocks and distribute fuels, and operations that provide inputs such as fertilizer and purchased energy.

Such a vehicle-fuel system is the subject of attributional LCA as traditionally conducted. It excludes indirect, market-mediated effects outside the system boundary, such as interactions with global commodity markets for energy and for the agricultural products that in turn affect land use. Evaluating market effects requires economic modeling, resulting in the very large and, practically speaking, irreducible uncertainties that bedevil discussions of biofuels and climate. A narrow analysis of direct carbon exchanges cannot provide a complete answer to the question of a biofuel's GHG emissions impact globally. However, it can assess the extent to which CO_2 uptake in feedstocks suffices to offset CO_2 emissions from fuel combustion, providing a bounding result relevant to the broader question. Although indirect effects can be negative (reducing net emissions) or positive, they are dominated by carbon stock releases due to land-use change (Fargione et al. 2008; Searchinger et al. 2008; Melillo et al. 2009). Therefore, evaluating the offset observable within the vehicle-fuel system provides an upper bound on the net overall offset.

2 Method

Evaluating the direct carbon exchanges associated with a given physical system is conceptually straightforward. DeCicco (2012) proposed an Annual Basis Carbon (ABC) accounting method that treats all carbon flows in a spatially and temporally explicit manner. Unlike LCA or other forms of carbon accounting used for climate policy to date, it does not treat biofuels as inherently carbon neutral. Instead, it tallies CO_2 emissions on the basis of chemistry in the specific locations where they occur. ABC accounting reflects the stock-and-flow nature of the carbon cycle, recognizing that changes in the atmospheric stock depend on both inflows and outflows, while LCA focuses only on inflows (GHGs discharged into the atmosphere). It also conforms to a methodology that calls for a consistent system boundary that encompasses both biofuel and fossil fuel pathways (Schlamadinger et al. 1997).

Figure 1 depicts the vehicle-fuel system to be analyzed in terms of material carbon flows, referring to carbon that originates in feedstocks and is utilized as fuel, emitted during processing or exits the system in some other material form. These flows exclude other system inputs and outputs (such as natural gas or other fuels used for process energy and their associated GHG emissions), whose molecular carbon is not part of a feedstock-to-fuel material pathway. Those purely process-related emissions are evaluated separately in a manner similar to that of LCA. The extent to which end-use CO_2 is balanced by CO_2 uptake is a function of the carbon exchanges shown in Fig. 1. Flows along the top of the diagram are CO_2 exchanges between the system and the atmosphere; flows along the bottom are exchanges of material carbon, in either biomass leaving the system or crude oil entering it, with external systems. Cropland is within the system boundary and so ABC analysis counts carbon uptake regardless of the extent of biofuel use. Although the carbon in biomass output from the system is eventually emitted as CO_2 when feed and food products are consumed, these emissions occur outside the vehicle-fuel system and are mediated by complex displacement effects, as described later.

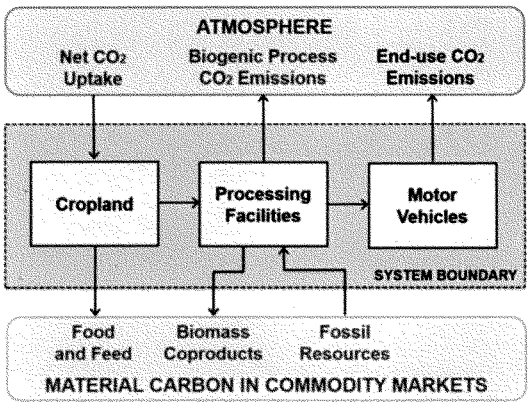

Fig. 1 Material carbon flows relevant to the substitution of a biofuel for a fossil fuel

2.1 Evaluating carbon uptake

The net amount of carbon taken up by vegetation is net primary production (NPP), which for annual crops ends up in one of several places. A significant portion ends up in the harvest and is removed from the cropland. A portion may accumulate as soil organic carbon (SOC). Some may be lost as organic matter carried by farm runoff or blown from the field by the wind, and some may be oxidized by fire or other non-biological process. A large portion decomposes or is consumed by organisms foraging on the land itself, comprising local heterotrophic respiration (R_h). Net ecosystem production (NEP) is the difference between NPP and R_h and it represents the net downward flow of CO_2 from the atmosphere in terrestrial ecosystems (Lovett et al. 2006). NEP is not necessarily the same as ongoing carbon accumulation on land; rather, it is the portion of NPP that becomes material carbon available for local sequestration or other disposition.

For a biofuel to provide a net reduction in CO_2 emissions, the production of its feedstock must effect a gain in NEP (DeCicco 2013). In other words, it is not sufficient for the feedstock to have merely removed carbon from the atmosphere. Rather, there must be an increase the *rate* of carbon removal, a test written as:

$$\mathrm{d(NEP)/dt} > 0 \tag{1}$$

This condition formalizes the Searchinger (2010) insight about "the need for additional carbon." It can be evaluated over a period of time by calculating:

$$\Delta\mathrm{NEP} = \mathrm{NEP}_{t1} - \mathrm{NEP}_{t0} \tag{2}$$

where t_n is a time index (year).

For this analysis, we estimate NEP over 2005–2013 and evaluate ΔNEP both annually and cumulatively over the period using crop data from the U.S. Department of Agriculture (USDA). From Lovett et al. (2006):

$$\mathrm{NEP} = \mathrm{NPP} - R_h = H + \Delta\mathrm{SOC} + E_x + O_x \tag{3}$$

Here, H is the *carbon harvest*, that is, the mass of the carbon embodied in the crops harvested. ΔSOC is the change in soil organic carbon on the cropland; E_x is carbon removed from the

land by runoff, leaching or wind; and O_x is carbon oxidized non-biologically, e.g., through fire. As explained in the appendix, for annual cropland E_x and O_x are small enough to omit and ΔSOC does not differ significantly from zero. We therefore assume NEP $\approx$ H and estimate annual changes in net carbon uptake as:

$$\Delta NEP_t = \sum_i H_{i,t} - H_{i,t-1} \quad (4)$$

where

$H_{i,t}$ carbon harvest of crop "i" at time "t" (a given year), and
$H_{i,t-1}$ carbon harvest of crop "i" at time "t-1" (the prior year).
Because harvest data reflect yield gains, increases in carbon uptake due to agricultural intensification are reflected in these estimates of NEP.

2.2 Other material carbon flows

Regarding the other flows depicted in Fig. 1, end-use CO_2 emissions from motor vehicles are readily computed from fuel consumption data. For biofuels at commercial scale to date, the only significant biogenic process emission is the CO_2 during ethanol fermentation. Biofuel coproducts are calculated using biorefining yield factors. The carbon exported to food and feed markets is computed by subtracting the coproduct carbon plus fuel end-use and biogenic process CO_2 emissions from the carbon harvest. The fossil carbon input is computed from an average well-to-pump processing factor for crude oil to gasoline and diesel fuel.

2.3 Other processing emissions and displacement effects

In addition to the CO_2 released through processing or combustion of material carbon, other GHGs are directly released from the system as a result of energy use and other processes within the respective fuel supply chains. These emissions are commonly modeled by attributional LCA and for our purposes there is no need to analyze them independently. We use parameters from EPA (2010b) to make this part of the analysis consistent with EPA's RFS analysis [A1(a)].[1]

Changes in flows of material carbon across the system boundary result in changes in the amount of carbon available to the rest of the economy nationally and internationally, causing market-mediated effects of varying sign and magnitude (Hertel et al. 2010). Because they require economic modeling based on limited data, the net impact of such displacement effects is highly uncertain. They include product and co-product substitution, changes in food and feed consumption, agricultural intensification (yield gain) and expansion (land-use change), and petroleum market rebound.

We do not evaluate these displacements but rather cite previously published estimates to put our vehicle-fuel system results in perspective. Overall, displacement effects increase the GHG releases from biofuel use at least for several decades (Melillo et al. 2009; Mullins et al. 2011; Mosnier et al. 2013; Chen et al. 2014; among others). Plevin et al. (2015) show that the carbon releases due to ILUC, which can dominate displacement effects, are most likely to be quite large and very unlikely to be negligible. The net GHG emissions estimate obtained through our

[1] See specified appendix section in the supplemental information.

circumscribed ABC analysis therefore provides a lower bound for the overall (direct plus indirect) GHG emissions impact of existing biofuel systems.

3 Analysis

This section has three main parts. The first evaluates the material carbon balance for the vehicle-fuel system to estimate the biogenic carbon offset, comprising the paper's main result. The second and third parts address GHG emissions related to fuel processing and displacement effects, respectively.

3.1 Material carbon balance

We calculate vehicle end-use CO_2 emissions using fuel carbon content data from EPA (2010b) and fuel consumption data from EIA (2015). Figure 2 shows the resulting estimates in TgC/yr (carbon rather than CO_2 mass basis; 1 Tg = 10^{12} g). The rate at which motor fuel carbon flows into the air declined by 23 TgC/yr, or 5 %, from 455 to 432 TgC/yr over 2005–2013, due to the 2008 recession and vehicle efficiency gains [A1(e)]. However, the biofuel portion of tailpipe CO_2 emissions rose from 6.5 TgC/yr in 2005 to 24.1 TgC/yr in 2013. In 2013, biofuels accounted for 5.8 % of motor fuel energy end-use and 5.6 % of tailpipe CO_2 emissions, up from a 1.4 % share in 2005.

The other component of biogenic emissions occurs during ethanol fermentation, which yields one mole of CO_2 per mole of C_2H_5OH produced. This release reached 10.2 TgC/yr in 2013. Combined with biofuel end-use CO_2 emissions, the overall increase in motor fuel-related biogenic emissions was 25 TgC/yr. In policy-oriented carbon accounting to date, these biogenic emissions are treated as carbon neutral. In ABC accounting, how much they are actually "neutralized" (offset) by gains in carbon uptake is a question to be addressed.

3.1.1 Carbon uptake on cropland

To estimate CO_2 uptake on cropland we used Annual Crop Production (ACP) data from the National Agricultural Statistical Service (NASS; USDA 2015), including planted area, harvested area, average yield and production by crop. For tractability, the analysis was limited to crops that covered at least 95 % of U.S. cropland according to the USDA Cropland Data Layer

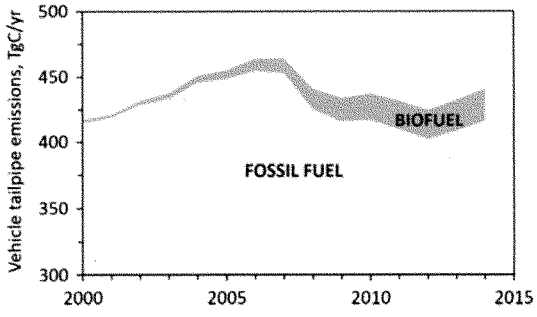

Fig. 2 Direct carbon emissions from U.S. motor fuel use, 2000–2014. Source: derived from EIA (2015)

in 2013. We did not attempt to estimate overseas carbon uptake for the small portion of biofuel that was imported, which averaged 5 % of U.S. biofuel consumption over 2005–13 [A1(f)]. Uptake was calculated by multiplying crop production by the fraction of carbon in each crop from composition data adjusted for moisture content [A2]. As shown in Fig. 3, net CO_2 uptake rose from 195 to 215 TgC/yr over 2005–2013. These estimates of NEP reflect the downward flow of carbon from the atmosphere into the part of the biosphere occupied by U.S. cropland.

Carbon uptake is dominated by corn, which has the largest planted area and a higher yield than other crops. The carbon harvest from corn alone rose by 25 TgC/yr over the analysis period due to a 17 % increase in planted area and a 7 % increase in yield. The corn-soy rotation is the most extensive U.S. farming practice and soybeans are second to corn basis in planted area. However, soybean yields average less than one-third those of corn by volume and only about 25 % those of corn on a carbon basis. With increases of 6 % in planted area and 2 % in yield, soybeans saw a carbon harvest gain of 2 TgC/yr. Nearly all other U.S. field crops saw their planted areas decline over the period. Sorghum was an exception; however, its yield fell and so its harvest did not change significantly. Among other crops, only wheat had a measurable gain in carbon harvest, but by only 0.3 TgC/yr. Collectively, harvests fell for all other major crops, mainly because of smaller planted area, netting out to an aggregate carbon harvest increase of 20 TgC/yr (about 10 %) over 2005–2013.

3.1.2 The biogenic carbon offset

The observed increases in carbon harvest provide estimates of the increases in NEP over the analysis period. Being smaller than the 25 TgC/yr increase in biogenic CO_2 emissions associated with biofuel use, it is not enough to fully offset those emissions. Because cropland NEP varies annually with economically-driven crop planting decisions and weather-dependent harvest outcomes, the overall offset is estimated by comparing cumulative gains in NEP to cumulative biogenic emissions. These calculations are given in Table 1.

The first section of the table shows year-by-year ΔNEP (first differences of the annual carbon harvest values shown in Fig. 3) and the gains in NEP and biogenic emissions relative to 2005. Because NEP is a flow (TgC yr^{-1}), ΔNEP is the derivative of a flow and has TgC yr^{-2} as its unit. Being based on harvest data, the annual ΔNEP can be positive (a gain in uptake) or negative (e.g., due to a poor growing season). As shown in the table, the aggregate harvest as measured on a carbon basis fell in 2006, meaning that the flow rate of CO_2 from the

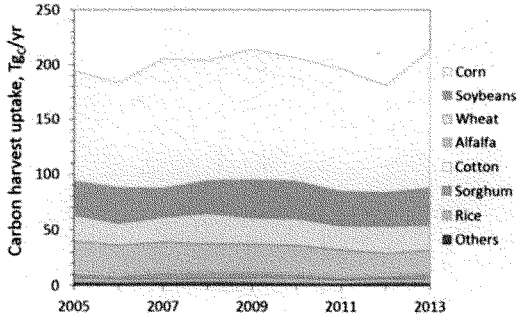

Fig. 3 Carbon uptake on U.S. cropland, 2005–2013. Source: derived from USDA (2015)

Table 1 Biogenic carbon emissions compared to net gains in carbon uptake

Annual changes	2006	2007	2008	2009	2010	2011	2012	2013
ΔNEP (TgC yr^{-2})	−11.5	22.5	−2.3	10.3	−7.2	−10.2	−13.3	31.5
Net NEP gain (TgC yr^{-1})	−11.5	11.0	8.7	19.0	11.8	1.6	−11.7	19.8
Biogenic emissions (")	3.7	7.2	13.6	16.7	20.8	22.5	22.5	24.7
Cumulative effects (running sum, TgC)								
Additional C uptake	−11.5	−0.5	8.2	27.2	39.0	40.6	28.9	48.7
Biogenic emissions	3.7	11.0	24.5	41.2	62.0	84.5	107.1	131.8
Net carbon emissions	15.2	11.5	16.3	14.0	23.0	43.9	78.2	83.1
Percent offset	−308 %	−5 %	33 %	66 %	63 %	48 %	27 %	37 %

atmosphere to cropland declined, giving a negative value for ΔNEP that year. It jumped in 2007 due to a better growing season but also because notably more corn was planted that year. The annual variability of NEP is reflected in the changing sign of ΔNEP throughout the period.

Integrating ΔNEP gives the net change in the rate of carbon uptake since the base year (2005), as shown by the "Net NEP gain" row in Table 1. By 2013, the net gain in NEP was nearly 20 TgC/yr, as can be seen in Fig. 3. To determine cumulative additional CO_2 removal from the atmosphere, we integrate again by taking the running sum of the annual gain in NEP. As the integral of a mass flow rate, the resulting values have units of mass (TgC, i.e., millions of metric tons). These results for additional CO_2 removal are shown as "Additional C uptake" in the cumulative effects section of the table and plotted as the green line in Fig. 4.

Similar calculations are performed for the biogenic CO_2 emissions. As shown in Table 1, biogenic emissions increase annually because biofuel production rose steadily over the 2005–2013 period. The cumulative amount of biogenic CO_2 that entered the atmosphere is obtained by integrating this flow, yielding the values plotted in black in Fig. 4. By the end of the period, cumulative biogenic emissions reach 132 TgC. Cumulative net uptake, which reflects the additional amount of carbon removed from the atmosphere by the cropland beyond what was removed in the base year, sums to 49 TgC. The difference between the biogenic carbon emitted and the additional carbon uptake is shown in Fig. 4 as the carbon neutrality "gap," which reaches 83 TgC by 2013. This value reflects the extent to which biogenic emissions exceeded additional carbon uptake over the analysis period.

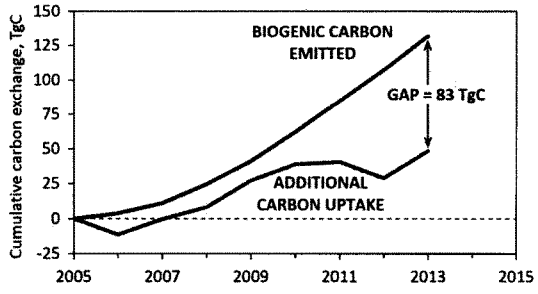

Fig. 4 Cumulative carbon emitted by U.S. biofuel use compared to cumulative additional carbon uptake on cropland

The last line of Table 1 compares cumulative carbon uptake and biogenic emissions in percentage terms, indicating that the additional uptake was enough to offset only 37 % of the increase in biogenic emissions from 2005 to 2013. This result shows that full carbon neutrality (a 100 % offset) fails for renewable fuel use in the United States over this period. It also shows how the extent of offset depends on the growing season. Because harvests fell in 2006 compared to 2005 (when the RFS was passed), the percent offset is very negative in 2006 and does not become positive until 2008. The cumulative offset reaches a high of 66 % of cumulative biogenic emissions in 2009 before falling again. Although subsequent years of data are needed to make a longer-term estimate, even if biofuel production levels off it seems unlikely that the cumulative offset would reach 100 % anytime soon.

3.1.3 Vehicle-fuel system carbon balance

Estimates of the material carbon flows defined in Fig. 1 can be used to construct a carbon mass balance for the vehicle-fuel system, showing inputs by source and outputs according to their disposition [A1(b)]. These balances, which exclude non-material-carbon process emissions, are depicted in Fig. 5.

The carbon harvest is either output from the system as food and feed or refined into biofuel. Some carbon is emitted as CO_2 during biorefining and petroleum refining. In biorefining, the primary coproduct is distiller's grain, which is supplied for use as animal feed [A1(c)]. For petroleum refining, the process CO_2 emissions estimate assumes a well-to-tank energy efficiency of 81.7 % [A1(d)].

In Fig. 5, the sum of input carbon flows matches the sum of the output flows each year. The total rate of carbon flow through the system fell from 745 TgC/yr in 2005 to 715 TgC/yr in 2013, largely due to lower motor fuel demand. Although all of the biogenic carbon emitted comes from NEP (the gross carbon harvest), the gain in NEP over 2005–2013 does not produce enough additional carbon to cover the sum of that which substitutes for fossil carbon in motor fuel plus what gets released during processing. Because the increase in carbon harvest is less than the decrease in fossil carbon input, fuel demand is met at the expense of carbon supplied to the food and feed system. Thus, Fig. 5 reflects how ABC accounting respects conservation of mass (carbon), in contrast to LCA, which does not ensure conservation of mass because it fails to properly assess carbon uptake.

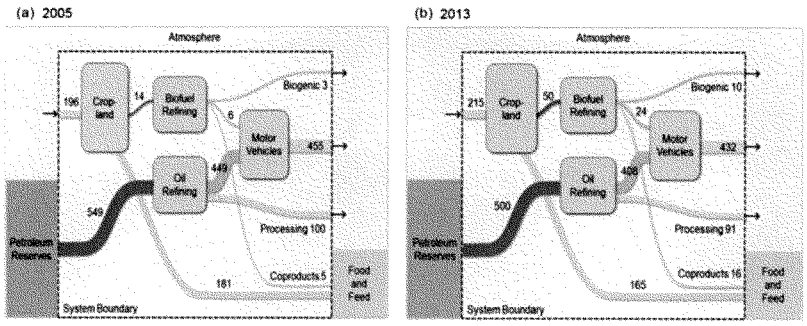

Fig. 5 Material carbon flows through the U.S. vehicle-fuel system (TgC/yr)

3.2 Process GHG emissions

In addition to fuel-related material carbon emissions, GHGs are emitted from feedstock and fuel processing operations. These emissions are the traditional focus of LCA and there is no need to revisit their estimation here. For comparison purposes, we use process emission factors from EPA (2010b).

Adding process emissions to material CO_2 emissions yields total net GHG emissions from the vehicle-fuel system, which dropped by 38 TgC/yr from 2005 to 2013, i.e., by about 10 % of base year emissions (calculations given in appendix Table A2). This drop is explained by a combination of greater carbon uptake (tallied as negative emissions), lower petroleum input and lower overall fuel demand. GHG emissions from fuel processing increase due to the greater amounts of energy and other inputs needed for producing biofuels compared to petroleum fuels. As seen in Fig. 5, there was a loss of biomass carbon output from the system. Therefore, although the system's net GHG emissions fell, the decrease is only partly from a gain in carbon uptake tied to biofuel use. In gross terms, the 20 TgC/yr increase in NEP explains just over half of the 38 TgC/yr GHG reduction, but that is before considering other important effects such as reduced fuel demand.

3.3 Displacement effects

Changes in flows of material carbon across the system boundary change the amount of carbon available to the rest of the economy nationally and internationally. Many effects are indirect, as changes in supply and demand cause changes in price that affect petroleum fuels, grains and other farm products as well as their coproducts, substitutes and other items, affecting GHG emissions the associated markets. These effects include:

- Substitution of agricultural products (including co-products)
- Deprivation of agricultural products (reduced feed and food consumption)
- Intensification of agriculture (increased yield)
- Expansion of agriculture (direct and indirect land-use change)
- Petroleum market rebound (higher demand in non-regulated fuel markets)

Substitution, deprivation and intensification decrease net GHG emissions due to biofuel use while expansion and rebound effects increase net emissions. Because it involves a release of carbon stocks, agricultural expansion can have a very large impact. The other effects involve marginal changes but have magnitudes significant relative to the direct impacts of the vehicle-fuel system. Modeling displacement effects is beyond the scope of this study and so we use estimates from the literature, acknowledging their very high uncertainty due to market behavior, differences in modeling methods and data limitations.

Substitution effects are captured by EPA's RFS analysis and so are reflected in the process emissions estimates (Table A2). Evaluating deprivation effects is a new area of research; they may be on the order of one-third of biogenic end-use emissions (Searchinger et al. 2015). Agricultural intensification on U.S. cropland is reflected in the harvest data and so are reflected in our carbon uptake results; we did not attempt to estimate intensification internationally. Petroleum market rebound can amount to as much as one-half of the petroleum fuel displaced by biofuel, raising CO_2 emissions in other markets (Chen et al. 2014). The net impact of these interactions is highly uncertain and so it is difficult to ascertain whether their combined effect is either positive or negative.

The displacement effects that clearly increase biofuel-related carbon emissions are direct and indirect land-use change (DLUC and ILUC). For the RFS, EPA projected no significant

DLUC-induced release of carbon stocks and a small gain in soil carbon by 2022. Nevertheless, the available evidence does not support a gain in soil carbon to date [A4]. For DLUC, Lark et al. (2015) examined the 2008–12 subset of our 2005–13 analysis period and estimated a cumulative release of 36 TgC associated with the biofuel-related expansion of U.S. cropland [A5(a)].

For ILUC, EPA's RFS analysis amortizes carbon stock releases over a 30-year future time horizon. For ABC analysis, releases are counted in the years when they occur, and so we summed the EPA (2010c) projections of ILUC-induced CO_2 releases each year over 2005–2013, implying a cumulative 433 TgC release over the 8-year period [A5(b)]. Although any such projection is highly uncertain, the DLUC and ILUC releases clearly overwhelm the changes in direct vehicle-fuel systems emissions.

4 Discussion

These results demonstrate the value of going back to basics for addressing the CO_2 effects of biofuel use. ABC accounting focuses on the terms for which the best data are available and which can be evaluated with minimal reliance on assumptions. The analysis is therefore narrow in scope and does not attempt to quantify the overall GHG impact of biofuels production and use. ABC accounting does not replace LCA, but it does call LCA results into question, underscoring warnings about the method's ability to mislead (Plevin et al. 2014).

Because ABC accounting does not generate a lifecycle metric such as a CI value, its results cannot be directly compared to LCA results. Moreover, ABC accounting is sensitive to system dynamics, in contrast to LCA's treatment of a system as static over a defined lifecycle. Nevertheless, the finding of a 37 % offset of biogenic emissions over the period analyzed rather than the 100 % offset assumed in LCA highlights the discrepancy. For example, take a typical attributional LCA result claiming that corn ethanol is 44 % less carbon intensive than petroleum gasoline (Wang et al. 2012). Using a 37 % offset of biogenic emissions instead of a 100 % offset would imply that corn ethanol is 27 % more carbon intensive than gasoline even before considering land-use change [A1(g)]. Of course, this ABC result is for a specific period of time and so makes no claim to offer a general characterization of corn ethanol. The method thereby respects the fact that the seemingly simple question of comparing the carbon intensity of one fuel to another is an ill-posed question empirically.

The differences between ABC accounting and LCA are more profound than numerical comparisons can reveal. One fundamental distinction is that the ABC approach treats biofuels as part of a dynamic stock-and-flow system. This differs from LCA, in which biofuel use is modeled as a static system, i.e., one presumed to be in equilibrium with the atmosphere in terms of its material carbon flow, that is compared to a distinct system involving the flow of fossil carbon into the atmosphere. A related difference is ABC accounting's explicit evaluation of additionality by tracking changes in carbon uptake (NEP) when feedstocks are sourced.

Although it does not address leakage, which would require global modeling, ABC accounting clearly delineates CO_2 flows between the vehicle-fuel system and the atmosphere from flows of material carbon with external markets. It thereby respects conservation of mass, which LCA-based fuel comparisons do not. This distinction highlights the weakness of even consequential LCA methods that fail to evaluate additionality but claim to offer correct carbon accounting because they model leakage effects such as ILUC. Finally, the core aspects of ABC accounting – including its estimation of the extent of offset – have a low level of uncertainty

because the carbon uptake and vehicle emissions estimates reflect the composition of directly measured material flows for feedstocks and fuels.

This paper does not attempt a consequential analysis, which would entail modeling a counterfactual scenario against which actual 2005–2013 carbon exchanges are compared. Such an analysis is left for future work. More broadly, there is a need to develop analytic tools with a resolution and transparency suitable for addressing sectoral measures that target transportation fuels. Liquid fuels can couple strongly to energy and agricultural markets and therefore require dynamic analysis, ideally using commodity data for empirical validation as done here. It would be useful to conduct ABC evaluations of other programs, such as California's LCFS. The method can also prospectively assess emerging biofuel technologies that process cellulosic feedstocks. Such options may enable greater gains in NEP, e.g., by using crop residues that reduce R_h or by using feedstocks that raise NPP. Finally, given how different this approach is from the methods commonly used for energy analysis, further work is needed to examine the research and policy implications going forward.

5 Conclusion

This retrospective, national-scale evaluation of substituting biofuels for petroleum fuels applied Annual Basis Carbon accounting to take a circumscribed look at the changes in carbon flows directly associated with a vehicle-fuel system. The system was defined to include motor fuel consumption, fuel processing operations and resource inputs, including cropland for biofuel feedstocks. The assumption that biofuels are inherently carbon neutral is a premise of most climate-related fuel policies promulgated to date, including measures such as the LCFS and RFS that evaluate GHG impacts using lifecycle modeling. However, this analysis found that the gains in CO_2 uptake by feedstock were enough to offset biofuel-related biogenic CO_2 emissions by only 37 % over 2005–2013, showing that biofuel use fell well short of being carbon neutral even before considering process emissions.

When this estimate of the real-world offset is considered together with values from the literature for displacement effects, the conclusion is that rising U.S. biofuel use has been associated with a net increase rather than a net decrease in CO_2 emissions. This finding contrasts with those of LCA studies which indicate that even crop-based biofuels such as corn ethanol and soy biodiesel offer modest net GHG reductions. The global GHG impact of biofuel use remains highly uncertain. Nevertheless, the necessary condition for a biofuel to offer a CO_2 mitigation benefit, namely, that the production of its feedstock must increase NEP, can be evaluated empirically. Doing so provides a bounding result that suggests a need for greater caution regarding the role of biofuels in climate mitigation.

Acknowledgments The work reported here was supported by the American Petroleum Institute (API) and the University of Michigan Energy Institute (UMEI). The analysis, results and conclusions presented are those of the authors alone. The conclusions and views expressed do not necessarily, and should not be taken to, reflect those of either API or UMEI.

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Mr. POSEY. Thank you, Mr. Chairman.

According to his study, despite the purported advantages of biofuels created from crops such as corn, soybeans cause more emissions of climate-change-causing carbon dioxide than gasoline. The study further remarks that carbon neutrality has really been an assumption. To verify the extent to which the assumption is true, you really need to analyze what's going on in the farmland, where the biofuels are being grown. People haven't done this in the past, and they felt like they didn't need to.

It's truly puzzling to me that we aren't looking at the full lifecycle of biofuels production. With gasoline, we take into account not just the tailpipe emissions but carbon emissions during the drilling, the transportation, the refueling, and other parts of the process.

Now, Mr. Secretary, I'm working on legislation to authorize the Department of Energy to conduct research and development necessary to refine our models to better estimate the overall impact of ethanol fuels on greenhouse gas emissions. I believe it's essential that we have an accurate estimate of these impacts to develop policymaking on such fuels. Ethanol is a very pure poor fuel product substitute, and mandating its use has serious implications for food supplies and prices. Will you pledge to work with me on legislation to improve the basic tools necessary for assessing the lifecycles and emissions of ethanol?

Secretary PERRY. Yes, sir.

Mr. POSEY. Thank you. I yield back, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Posey.

And the gentleman from Illinois, Mr. Foster, is recognized.

Mr. FOSTER. Well, thank you.

And, Secretary Perry, I have to say how much I really enjoyed the day that we spent together visiting the two national labs that, you know, one of which I worked at for many years, another one which I currently represent. And, you know, I just want to say that your enthusiasm for the fundamental science has really shown through on that visit. You know, it's a—you know, the Department of Energy has done well with, you know, technical wizards running it and also with people with more political backgrounds who really understand and appreciate what it does. And I just want to say how much, you know, I appreciate that, as well as of course your specific enthusiasms for the upgrades at Argonne and at Fermilab, which have already been mentioned here.

Also, you know, when I look over, you know, the subject of this and the budget, you know, we've had some sort of off-the-record discussions there, and you mentioned in your opening remarks the return on investment, which I think is the right phrase for this. And so when you look at programs like the EERE investments where third-party independent estimates have said that between—the investments between 1976 and 2008 of about $15 billion generated economic benefits to the United States of about $388 billion. And that's a return on investment of 24 to 1, an enormous number, and you'd be hard-pressed to find any industrial sector with a comparable return on investment. And, you know, you definitely get that.

And, you know, on the other hand if you look at this—at the budget proposal, you're going to—you know, there are things like the Loan Program Office of the Advanced Tech Vehicle Manufacturing program. These are things that have turned a profit for the taxpayer in the sense of returned money to the taxpayer. So technically, the return on investment there is more than infinite. And yet when you see these things proposed to be zeroed out, you know, how do you react in the internal debates on that, and how do you go forward when you, I'm confident, advocate for this sort of program and then see the final proposal——

Secretary PERRY. Yes, sir.

Mr. FOSTER. —being cut?

Secretary PERRY. Mr. Foster, as you said, you and I have had some relatively lengthy conversations about this specific area of the budget. As—I try to remind people that, again, I really respect this process. I grew up in it having been an appropriator, having been an agency head, having been the chief executive of a State that was fairly successful. We actually created a program back in Texas called the Emerging Technology Fund that we oversaw, and I argued vehemently to some of my own colleagues on my political party that didn't think government needed to be picking winners and losers, and I shared with them that we pick winners and losers every day.

Mr. FOSTER. Yes, but——

Secretary PERRY. But my——

Mr. FOSTER. —I just—I really appreciate—you know, you actually get this issue in-depth, and I just really appreciate that. So keep fighting, and I wish you better luck in future debates here.

Now to change the subject, your predecessor, one of the really great things he did with the scientific expertise of the national lab was to—and really engaged that expertise in the Iran nuclear negotiations, that he was providing real-time input to the negotiating team and to those of our allies on the detailed technical questions that are an essential part of this. So could you describe the extent to which the—that technical and scientific expertise at the national labs, both the science labs and the weapons labs have been engaged in the latest strategic decisions by the White House?

Secretary PERRY. Yes. And it's a lot broader. I know news of the day is the Iranian deal, the JCPOA, but the point is the Department of Energy is the agency of which the verification of nuclear materials and nuclear activities around the world, whether it's North Korea, whether it's Iran, our agency is where the expertise lies. National labs obviously play a very important role with that but also in the NNSA side of our house as well. So I'm not sure there is an agency of government with more expertise, with the——

Mr. FOSTER. So my question is why have seen very little evidence of that expertise being engaged or can you give specific examples where it has been in these latest decisions?

Secretary PERRY. Yes, sir, I can but I'm not sure that some of it we can talk about in this room.

Mr. FOSTER. Thank you. I appreciate that.

Secretary PERRY. Yes, sir. But I'll be more than happy to come and sit down with you in a classified environment and share with you I think the questions that you place forward.

Mr. FOSTER. Thank you.

Secretary PERRY. Yes, sir.

Mr. FOSTER. I yield back.

Chairman SMITH. Thank you, Mr. Foster.

The gentleman from Texas, Mr. Babin, is recognized for questions.

Mr. BABIN. Yes, sir, thank you, Mr. Chairman, and thank you, Mr. Secretary, for being here, my favorite Governor. Glad to have you here.

Secretary PERRY. Thank you.

Mr. BABIN. I appreciate your long years of service to our Lone Star State.

I would like to have a graph put up, please, from 2010 from the U.S. Energy Information Administration.

[Slide.]

Mr. BABIN. Let me make a note here. The graph all the way to the right, these are subsidies for unit of production per megawatt hour all the way to the right. That is not to scale. You can see for solar power the American taxpayers were subsidizing solar energy per megawatt hour at a rate—if that graph was to scale, we would have to be in about a three-story building. That's how high and how large the amount of subsidies that we are giving solar energy. You can see that wind is the next one. It is to scale. And then a few years later in 2013 solar is still way up there above everything else. It's declining but still unacceptably high as far as I'm concerned. This is probably the result of the Obama stimulus that was done at that point in time, thankfully winding down than anything else.

To the best of our knowledge this is the last time that the EIA has published this particular chart laying out just how much hard-working taxpayers in our district and across the country are paying for energy subsidies. What happened? Environmentalist groups, along with our allies in Congress and the Obama Administration, pushed for and apparently succeeded in keeping this very simple, easy-to-read chart away from the public eye.

I also have here the most recent report published just last month from 2016 which, Mr. Chairman, I'd like to enter into the record if that's possible.

Chairman SMITH. Without objection.

[The information follows:]

Independent Statistics & Analysis
U.S. Energy Information Administration

Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2016

April 2018

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

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- Bonnie West–coal and coal-related subsidies and support
- Chris Namovicz–loans and loan guarantees
- Aloulou Faouzi–natural gas and petroleum subsidies and support
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Preface

This report—an update based on Fiscal Year (FY) 2016 data—continues a series of U.S. Energy Information Administration (EIA) reports on federal direct financial interventions and subsidies into energy markets. Using a set of data sources and analytic procedures, EIA assigns within-scope U.S. tax and direct expenditures to a set of discrete energy system categories.

Contents

Tables

Figures

Overview and Key Findings

Overview

This report—an update based on Fiscal Year (FY) 2016 data and earlier EIA reports on direct federal financial interventions and subsidies in energy markets—continues a series of U.S. Energy Information Administration (EIA) reports[1] that began in response to congressional requests. More recently, the Secretary of Energy requested updated information as part of the U.S. Department of Energy's (DOE) Grid Resiliency Study.[2]

The scope of this EIA report is limited to direct federal financial interventions and subsidies, i.e., subsidies provided by the federal government, subsidies that provide a financial benefit with an identifiable federal budget impact, and subsidies that are specifically targeted at energy technologies and markets. State and local programs—although significant in a number of cases—have been excluded from EIA's reporting. As a result, this report does not encompass all subsidies that affect energy markets and should therefore be viewed in context and in conjunction with related information from other sources (see discussion of *Other energy subsidy studies* in the *Analytic Approach* section).

Consistent with EIA's independent role and mission, this report focuses on providing information to inform discussion rather than drawing conclusions or discussing policy issues related to energy subsidies. By using a comprehensive data acquisition and analysis process, EIA estimates how federal financial actions are distributed among a defined set of categories comprising the U.S. energy system.[3] EIA has made only limited observations of the scale, trends, and relationships within the data and the report tables.

Table 1 summarizes total within-scope energy subsidies and selected U.S. energy system indicators.

Subsidy types

Federal financial interventions and subsidies included in this report fall into four categories:

- **Tax expenditure:** the amount of tax benefits or preferences received by taxpayers and forgone by the federal government
- **Direct expenditures** to recipients (i.e., both producers and consumers): the amount of grants, loans, or other financial assistance awards made directly to recipients
- **Research and development** (R&D) support: the amount of grants, loans, or other financial assistance awards made for R&D

[1] The first EIA study was undertaken at the request of Congress in Fiscal Year (FY) 1992, pursuant to language appearing in the House Appropriations Committee's Report on the U.S. Energy Information Administration FY 1992 appropriations.
[2] U.S. Department of Energy, Staff Report to the Secretary on Electricity Markets and Reliability, Washington, DC, August 2017.
[3] EIA has requested further detailed data from the Internal Revenue Service as it pertains to the distribution of energy-related tax benefits.

- **DOE loan guarantees:** financial support authorized to be provided by DOE for innovative clean energy technologies that are typically unable to obtain conventional private financing because of their high technology risks.[4]

Table 1. Total energy subsidies and support and selected energy indicators, FY 2010, FY 2013, and FY 2016

trillion British thermal units or as specified

Indicators	FY 2010	FY 2013	FY 2016
Total Energy Subsidies and Support (million 2016 dollars)	**37,992**	**29,335**	**14,983**
U.S. Energy Consumption	**96,850**	**98,655**	**96,788**
U.S. Energy Production	**73,695**	**81,151**	**84,833**
U.S. Natural Gas (dry and liquids)	24,105	28,220	32,652
U.S. Crude Oil	11,512	15,370	18,797
U.S. Coal	21,657	20,223	14,807
U.S. Nuclear	8,318	8,099	8,352
U.S. Biomass	4,358	4,680	4,963
U.S. Hydroelectric	2,588	2,582	2,482
U.S. Wind	863	1,557	2,038
U.S. Solar	88	205	533
U.S. Geothermal	207	215	209

Note: Totals may not equal the sum of components due to independent rounding.

Sources: **Consumption:** EIA, *Monthly Energy Review*, February 2018, Table 1.3. **Production:** EIA, *Monthly Energy Review*, February 2018, Table 1.2. **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, FY 2012, 2015, and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1. **Federal direct expenditure and R&D expenditure subsidies**: DOE: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; FY 2010 and FY 2013: U.S. General Services Administration, USASpending.gov - Government spending at your fingertips, https://www.usaspending.gov/, accessed October 22, 2014; FY 2016: U.S. Department of the Treasury, USASpending.gov, https://www.usaspending.gov/, accessed November 16, 2017. **Loan guarantee programs credit subsidy**: Computed from data from U.S. Department of Energy, Loan Program Office, https://www.energy.gov/lpo/portfolio/portfolio-projects, accessed January 20, 2015 and EIA, *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010*, July 2011, Table 29.

[4] Section 1703 of Title XVII of the Energy Policy Act of 2005 authorizes the U.S. Department of Energy to support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risks. In addition, the technologies must avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases. The *Advanced Technology Vehicles Manufacturing* (ATVM) Loan Program was established in Section 136 of the Energy Independence and Security Act of 2007 to support the production of fuel-efficient, advanced technology vehicles and qualifying components in the United States. American Recovery and Reinvestment Act of 2009 amended Loan Guarantee Program's authorizing legislation, creating Section 1705.

Key findings

Table 3 and Table 4 summarize the allocation of federal direct financial interventions in U.S. energy markets by subsidy type. Several key findings stand out.

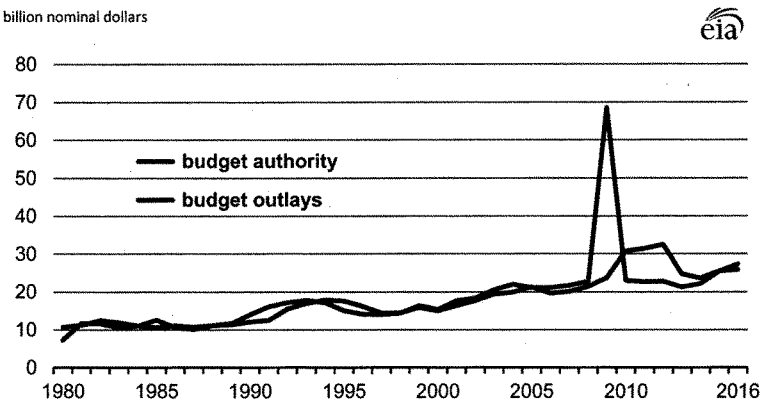
The scope and complexity of federal financial and award activities are very large and spread over a wide range of sources, recipients, and time frames. Despite a recent trend of decreasing federal activity, hundreds of distinct energy-related federal financial programs continue to pursue a wide range of goals using various methods. The time frames of these programs and activities can be very different, as in the case of tax provisions that allow taxpayers to decide which year to take a credit or to pay a deferred charge. Isolating the impacts of these programs, as well as characterizing the net impact of the whole set of actions on the U.S. energy system, is challenging.

Most current federal subsidies support developing renewable energy supplies (primarily biofuels, wind, and solar) and reducing energy consumption through energy efficiency. In FY 2016, nearly half (45%) of federal energy subsidies were associated with renewable energy, and 42% were associated with energy end uses. Table 4 shows a more detailed distribution of renewable energy-related federal support. The amount and distribution of renewable energy subsidies over time (see text box on *renewable-related subsidy trends*) have depended on congressional authorizations and the market competitiveness of renewable electricity technologies. Among renewable technologies, biofuels received the only incremental increase in FY 2016 subsidy support, driven by greater domestic biomass-based diesel production and foreign imports of these products that resulted in an approximately $1 billion increase in tax credits from FY 2013 levels.

Energy end-use and conservation subsidies decreased from $7.7 billion in FY 2013 to $7.2 billion in FY 2016 (Table 3). The largest program in this combined category–the Low Income Home Energy Assistance Program (LIHEAP) operated through the U.S. Department of Health and Human Services (HHS)–maintained its funding levels at $3.2 billion and $3.4 billion in FY 2013 and FY 2016, respectively. The decrease in total subsidies and support for energy-related conservation and end-use programs between FY 2013 and FY 2016 was led by declines in direct expenditures, which decreased from $4.2 billion to $3.6 billion, respectively. Of the $438 million decline in total federal support of conservation and end-use programs between FY 2013 and FY 2016, direct expenditures decreased $597 million. The tax credit for energy efficiency improvements to existing homes (26 U.S.C. 25C) accounted for $106 million of the decrease, and conversely, many tax expenditures (e.g., the credit for residential energy efficient property, 26 U.S.C. 25D) increased during the same period.

Since FY 2010, the scale of federal support has decreased as temporary measures expired, even as the U.S. energy system continues to grow. Federal activities within the scope of this study have been decreasing, in large part because of the expiration of provisions and programs authorized by the American Recovery and Reinvestment Act (ARRA or the Recovery Act) of 2009 (Figure 1). The Recovery Act provided energy funding that greatly increased DOE's previous energy program budgets but also required the rapid obligation of funds that would cover outlays over several years. The U.S. energy system, as a whole, continues to grow, with production activities growing more rapidly than energy consumption. As a result, the relative scale of federal activity within the overall context of the energy system has continued to decline since FY 2010.

Figure 1. U.S. Department of Energy budget authority and outlays (FY 1980-FY 2016)



Source: Office of Management and Budget, Historical Tables, Tables 4.1 and 5.2, accessed February 23, 2018.

In FY 2016, tax code provisions were the largest source of direct federal financial interventions and subsidies in energy markets, following a period of higher federal direct expenditures resulting from ARRA programs and funding. The federal tax code—with 36 wide-ranging, energy-specific tax provisions (Table 5)—provided greater financial support to energy in FY 2016 than direct expenditures and R&D support. This reversal from FY 2013 is best captured by the temporary ARRA Section 1603-grant program to allow an investment tax credit (ITC)[5] in lieu of the renewable energy production tax credit (PTC).[6] In FY 2013, this ITC grant program pushed the direct expenditure category above estimated tax expenditures in absolute dollar terms.[7] In FY 2016, the ITC grant program had largely ended, and tax expenditures (in total) regained their dominance, with tax provisions representing 59% of the total (Table 3).

No new DOE loan guarantees were issued in either FY 2013 or FY 2016. The subsidy cost of the loans issued in FY 2010 totaled $1.7 billion. Because this cost is assessed at the time the loan is issued, there was no related subsidy cost for FY 2013 or FY 2016. The loan guarantees associated with the Vogtle nuclear project[8] are included with FY 2010 subsidy costs. However, there were still outstanding debts in FY 2016 for loans issued in prior years. Although lending authority for the Section 1705 loan program had expired by 2013, budget authority remains for future lending on the Section 1703 loan program.

[5] This report will reference only renewable electricity investment (i.e., energy investment credit) as the ITC.
[6] This report will reference only renewable electricity production (i.e., energy production credit) as the PTC.
[7] This categorical shift can be viewed as an accounting issue, with the subsidy still ultimately stemming from the tax code.
[8] DOE, Loan Guarantee Office, website: https://energy.gov/lpo/vogtle, accessed February 20, 2018. On September 29, 2017, the U.S. Department of Energy offered conditional commitments for construction to the Vogtle project, website: https://energy.gov/lpo/articles/vogtle-conditional-commitments-support-energy-infrastructure, accessed February 27, 2018.

Electricity projects accounted for 25% of FY 2016 total R&D expenditures. This share is similar to the share in FY 2010 and FY 2013. Except for biofuels, virtually all non-fossil energy subsidies (renewable fuel and nuclear) were for electricity projects. In addition, most coal subsidies were electricity-related, even though they were often not denoted as such, because about 85% of coal consumption is used to generate electricity. The share of natural gas subsidies for electricity generation is more difficult to determine.

Table 2. Measures of electricity net generation and growth (FY 2000 versus FY 2016)

Beneficiary	2000 Net Generation (billion kilowatt-hours)	2016 Net Generation (billion kilowatt-hours)	Share of 2000 Generation (percent)	Share of 2016 Generation (percent)	Annual Growth from 2000 to 2016 (percent)
Coal	1,931	1,208	51.4	29.6	(2.9)
Natural Gas and Petroleum Liquids	684	1,431	18.2	35.1	4.7
Nuclear	765	799	20.4	19.6	0.3
Other	13	21	0.3	0.5	3.1
Renewables	**365**	**618**	**9.7**	**15.2**	**3.3**
Biomass	59	63	1.6	1.5	0.4
Geothermal	15	16	0.4	0.4	0.5
Hydroelectric	286	268	7.6	6.6	(0.4)
Solar	1	51	0.0	1.2	31.8
Wind	5	220	0.1	5.4	26.3
Total	3,759	4,077	100.0	100.0	0.5

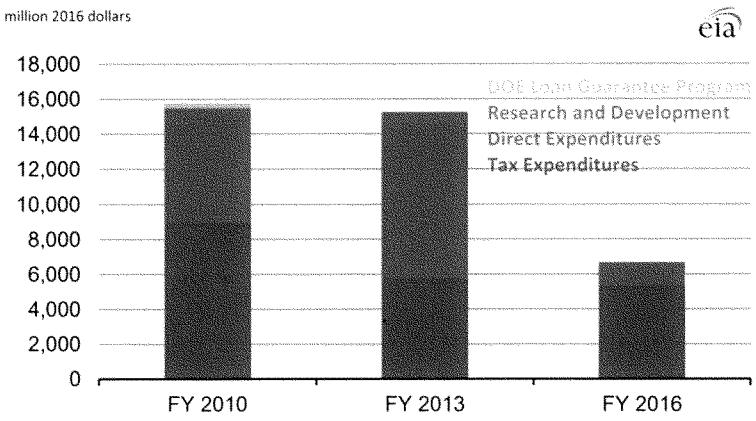
Notes: Totals may not equal sum of components due to independent rounding. A table value in brackets () denotes a negative value. Zero denotes rounding to zero value. *Other* includes net generation from hydroelectric pumped storage, other gases, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies. *Biomass* includes net generation from wood and waste. *Solar* includes distributed (small-scale) generation and utility-scale generation.

Sources: U.S. Energy Information Administration, *Monthly Energy Review*, February 2018, Table 10.6 (solar) and Table 7.2a (all other).

Textbox: Renewable-related subsidy trends

Renewable energy (including biofuels) comprised between 42% and 52% of total energy subsidies for each of the three fiscal years analyzed (Table 5). Total renewable-related subsidies were about $15.5 billion for both FY 2010 and FY 2013, then dropped to $6.7 billion in FY 2016 (Figure 2). Tax and direct expenditures combined accounted for about 93% of total renewable-related subsidies for each of the years analyzed. In FY 2016, tax expenditures alone accounted for 80% of total renewable energy subsidies. Direct expenditures decreased 90% from FY 2013 to FY 2016, largely as a result of the expiration of the Section 1603 grant program.

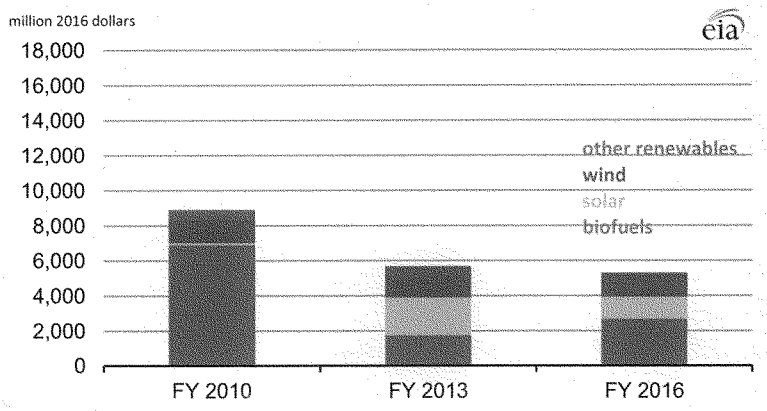
Figure 2. Renewable-related energy subsidies



Source: Table 4.

Renewable tax expenditures declined $367 million between FY 2013 and FY 2016, due almost entirely to lower outlays for the PTC for electricity plants (Figure 3). In previous years, the Section 1603 grant program was designed to achieve the same goals as the PTC (during years when investors had little tax liability) and represented a large portion of renewable energy subsidies. Changes in biofuel tax expenditures from FY 2010 to FY 2016 reflect the 2011 expiration of the alcohol fuel excise tax exemption followed by increasing expenditures associated with the biodiesel mixture credit (referred to as the biodiesel production tax credit in Table 5).

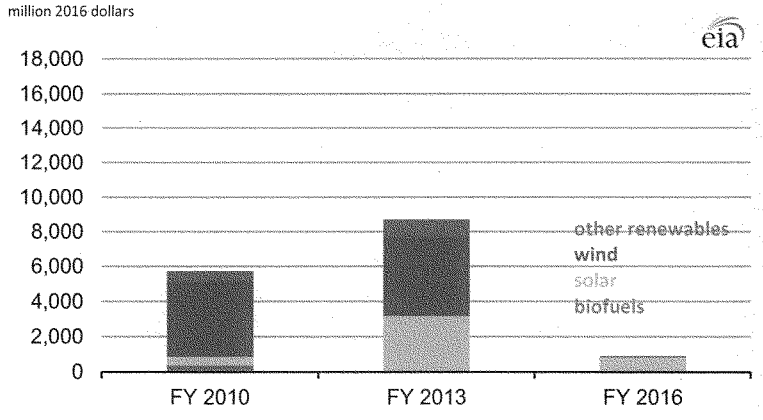
Figure 3. Renewable-related estimated tax expenditures



Source: Table 4.

Nearly all direct expenditures since FY 2010 for renewable-related energy have supported renewable electricity plant construction. Renewable-related direct expenditures were $5.7 billion and $8.7 billion in FY 2010 and FY 2013, respectively, which consisted mostly of payments in lieu of tax credits to construct wind plants (Figure 4). Solar and wind projects, when combined, received at least 82% of direct expenditures in each of the years analyzed.

Figure 4. Renewable-related direct expenditures

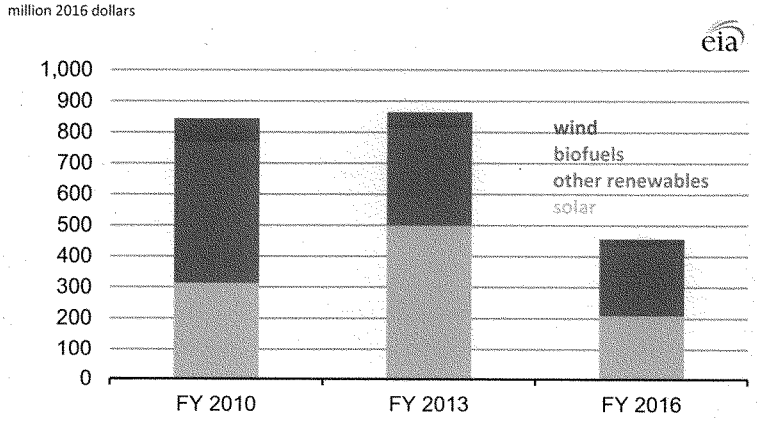


Source: Table 4.

Most direct expenditures between FY 2010 and FY 2016 were Section 1603 grants designed as alternatives to previous tax expenditure subsidies. The number of tax equity investors willing to make new investments after the 2008–09 recession decreased substantially, as few investors had tax liabilities to make the tax credits meaningful. To be eligible for the Section 1603 grant program, a project had to meet statutory requirements for starting construction and entering service. This provision resulted in substantial grant payouts continuing into FY 2010 and FY 2013. By FY 2016, however, grants had been paid to most eligible plants. The wide swings in investor demand for tax credits, coupled with direct expenditure program expiration dates, account for the large changes over the years analyzed.

Renewable energy research and development spending was about $850 million for FY 2010 and FY 2013, then dropped to $456 million for FY 2016 (Figure 5). Of the total renewable R&D subsides, electricity projects accounted for more than 80% of each year's subsidies, despite the large FY 2016 decrease in renewable-related R&D spending.

Figure 5. Renewable-related research and development expenditures



Source: Table 4.

Solar received the largest share of estimated renewable energy R&D funds for each of the years analyzed, ranging from 37% in FY 2010 to 58% in FY 2013. R&D spending dropped in FY 2016 for most renewable energy categories, with the exception of biofuels, which grew from $62 million in FY 2013 to $90 million in FY 2016.

Table 3. Quantified energy-specific subsidies and support by type, FY 2010, FY 2013, and FY 2016

million 2016 dollars, unless otherwise specified

Year and Support Type	Coal	Refined Coal	Natural Gas and Petroleum Liquids	Nuclear	Renewables	Electricity - Smart Grid and Transmission	Conservation	End Use	Total	Share of Total Subsidies and Support
2010										
Direct Expenditures	48	-	83	69	5,732	4	3,226	6,264	15,427	41%
Tax Expenditures	506	187	2,883	999	8,913	63	3,511	1,055	18,119	48%
Research and Development	320	-	10	177	844	566	704	97	2,718	7%
DOE Loan Guarantee Program	-	-	-	292	296	22	4	1,113	1,728	5%
Total	**875**	**187**	**2,976**	**1,537**	**15,785**	**655**	**7,446**	**8,530**	**37,992**	**100%**
Share of Total	**2%**	**0%**	**8%**	**4%**	**42%**	**2%**	**20%**	**22%**	**100%**	
2013										
Direct Expenditures	77	-	388	38	8,716	9	872	3,349	13,450	46%
Tax Expenditures	801	10	2,345	1,155	5,683	219	657	2,081	12,951	44%
Research and Development	216	-	64	197	864	887	517	189	2,934	10%
DOE Loan Guarantee Program	-	-	-	-	-	-	-	-	-	-
Total	**1,094**	**10**	**2,796**	**1,390**	**15,264**	**1,115**	**2,046**	**5,619**	**29,335**	**100%**
Share of Total	**4%**	**0%**	**10%**	**5%**	**52%**	**4%**	**7%**	**19%**	**100%**	
2016										
Direct Expenditures	19	-	111	40	909	11	234	3,391	4,716	31%
Tax Expenditures	906	-	(940)	160	5,316	160	560	2,653	8,816	59%
Research and Development	337	-	56	164	456	49	189	200	1,451	10%
DOE Loan Guarantee Program	-	-	-	-	-	-	-	-	-	-
Total	**1,262**	**-**	**(773)**	**365**	**6,682**	**220**	**983**	**6,244**	**14,983**	**100%**
Share of Total	**8%**	**-**	**(5%)**	**2%**	**45%**	**1%**	**7%**	**42%**	**100%**	

Notes: Totals may not equal sum of components due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Energy-specific tax expenditures associated with renewables were allocated based on preliminary generation data. No hydropower generation was assumed to be eligible for production tax credits (PTC). It was assumed all investment tax credits were claimed by solar power plants. Municipal Solid Waste (MSW) and open-loop biomass generation estimates used to calculate PTCs were halved to represent the value of their PTC credit, relative to geothermal and wind. Generation estimates for 2016 were used to calculate credits associated with the PTC for wind plants that came online in 2006 and later.

Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1. **Federal direct expenditure and R&D expenditure subsidies**: DOE: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; FYs 2010 and 2013: U.S. General Services Administration, USASpending.gov - Government spending at your fingertips, http://www.usaspending.gov/, accessed October 22, 2014; FY 2016: U.S. Department of the Treasury, USASpending.gov, http://www.usaspending.gov/, accessed November 16, 2017. **Loan guarantee programs credit subsidy**: Computed from data from U.S. Department of Energy, Loan Program Office, https://www.energy.gov/lpo/portfolio/portfolio-projects, accessed January 20, 2015 and EIA, *Direct Federal Financial Interventions and Subsidies in Fiscal Year 2010*, Table 29.

Table 4. Quantified renewable-related energy-specific subsidies and support by type, FY 2010, FY 2013, and FY 2016

million 2016 dollars, unless otherwise specified

	Renewable Electric									
Year and Support Type	Biomass	Geothermal	Hydroelectric	Solar	Wind	Other	Subtotal Renewable Electric	Biofuels	Total Renewables	Share of Total Renewables Subsidies
2010										
Direct Expenditures	185	67	63	481	4,241	330	5,369	363	5,732	36%
Tax Expenditures	575	1	19	132	1,297	-	2,023	6,890	8,913	56%
Research and Development	277	1	13	313	74	79	757	86	844	5%
DOE Loan Guarantee Program	-	13	-	190	94	-	297	-	296	2%
Total	**1,037**	**83**	**95**	**1,116**	**5,705**	**410**	**8,446**	**7,340**	**15,785**	**100%**
Share of Total Renewables	**7%**	**1%**	**1%**	**7%**	**36%**	**3%**	**54%**	**46%**	**100%**	
2013										
Direct Expenditures	346	325	205	3,094	4,454	218	8,642	75	8,716	57%
Tax Expenditures	48	32	18	2,164	1,682	-	3,944	1,740	5,683	37%
Research and Development	178	1	10	499	51	63	802	62	864	6%
DOE Loan Guarantee Program	-	-	-	-	-	-	-	-	-	-
Total	**572**	**358**	**233**	**5,756**	**6,187**	**280**	**13,387**	**1,878**	**15,264**	**100%**
Share of Total Renewables	**4%**	**2%**	**2%**	**38%**	**41%**	**2%**	**88%**	**12%**	**100%**	
2016										
Direct Expenditures	18	41	2	771	4	41	877	33	909	14%
Tax Expenditures	34	34	34	1,251	1,239	34	2,626	2,690	5,316	80%
Research and Development	27	10	2	209	24	95	367	90	456	7%
DOE Loan Guarantee Program	-	-	-	-	-	-	-	-	-	-
Total	**79**	**86**	**38**	**2,231**	**1,266**	**169**	**3,869**	**2,813**	**6,682**	**100%**
Share of Total Renewables	**1%**	**1%**	**1%**	**33%**	**19%**	**3%**	**58%**	**42%**	**100%**	

Notes: Totals may not equal sum of components due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Energy-specific tax expenditures associated with renewables were allocated based on preliminary generation data. No hydropower generation was assumed to be eligible for production tax credits (PTC). It was assumed all investment tax credits were claimed by solar power plants. Municipal Solid Waste (MSW) and open-loop biomass generation estimates used

to calculate PTCs were halved to represent the value of their PTC credit, relative to geothermal and wind. Generation estimates for 2016 were used to calculate credits associated with the PTC captured wind plants that came online in 2006 and later.

Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020, JCX-3-17 (Washington, DC, January 2017), Table 1, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1, and, computed from data from U.S. Energy Information Administration (EIA), Form EIA-923,"Annual Electric Utility Data". **Federal direct expenditure and R&D expenditure subsidies**: U.S. General Services Administration, USASpending.gov - Government spending at your fingertips, http://www.usaspending.gov/, accessed October 22, 2014 and U.S. Department of the Treasury, USASpending.gov, accessed November 16, 2017. **Loan guarantee programs credit subsidy**: Computed from data from U.S. Department of Energy, Loan Program Office, http://energy.gov/lpo/loan-programs-office, accessed January 20, 2015 and EIA, *Direct Federal Financial Interventions and Subsidies in Fiscal Years 2010*, July 2011, Table 29.

Limitations of this Report

Both the scope and the measurement of direct federal financial interventions and subsidies in energy markets are subject to limitations. This section addresses limitations in scope first, followed by limitations in measurement.

This report is limited in scope to a defined set of federal activities. These activities must meet a certain set of criteria for inclusion. They must

- be provided by the federal government
- provide a financial benefit with an identifiable federal budget impact
- be specifically targeted at energy markets

This scope does not include a wide range of more indirect or shared governmental activities that can provide financial benefits to energy market participants. For example, providing security to general infrastructure or tax provisions that apply to wide sets of equipment (i.e., applicable to both energy-related and non-energy-related) are types of federal activities that are not considered within this report's scope. The definition used in this report also excludes activities performed by federal staff or contractors, which can include energy technology development and direct energy purchases. Examples of such activities are noted in later sections.

Measurement limitations are an important consideration in the assessment of federal financial activities. Even a seemingly simple notion like the mismatch of fiscal, calendar, and tax years can result in the need to calculate, estimate, or interpolate figures, or to make different interpretations of an annualized benefit. Some fiscal year appropriations are not committed in a given fiscal year, and some obligated funds may not reach the intended recipients in the same fiscal year, leading to variability in the apparent pattern of federal activities over time. EIA provides a series of single-year estimates, not a continuous annual series, making specific events and broader trends more difficult to distinguish (as it is possible for any particular year's figures to be affected by unique factors). Finally, the estimation methods used by EIA are revised as new data and improved methods become available. While efforts are made to maintain consistency, improved estimation techniques take precedence over complete consistency with past editions of this report. EIA's treatment of measurement issues is discussed further in the Analytic Approach section.

Analytic Approach

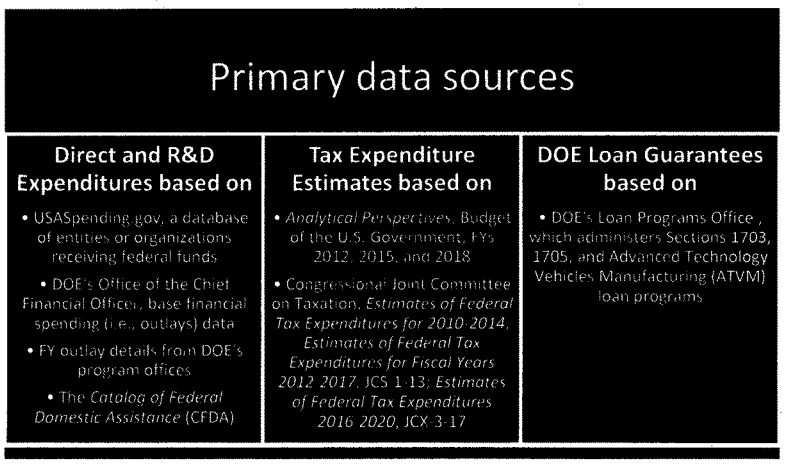
This report compiles direct federal financial interventions and subsidies in energy markets using federal government outlays (for DOE and the U.S. Department of the Treasury (the Treasury)), reported budget obligations (for all other federal departments), the estimated outlay equivalent value of tax expenditure estimates, and the subsidy value of DOE loan guarantees (Figure 6). The report then sorts or assigns all of the within-scope federal activities into one or more energy-specific categories within the U.S. energy system (biomass, coal, end use, etc.).

Goals. The primary goal of this report is to help people understand energy market interventions, specifically federal tax and direct expenditures that support various parts of the U.S. energy system. Consistent with this goal, EIA's final report tables are as simple as possible, despite the complexity of the data and the necessary analytic procedures. As noted in the Overview section, EIA has limited its observations of the scale, trends, and relationships within the data and the report tables.

Previous EIA studies. Since 1992, EIA has periodically updated this report. Prior reports and supporting materials are available from the EIA website.[9]

Data sources. EIA relies on several official governmental data sources as initial report inputs. Distinct data sources are used for tax expenditures, direct expenditures, and research and development expenditures, as well as amounts for DOE-related financial spending activities (Figure 6).

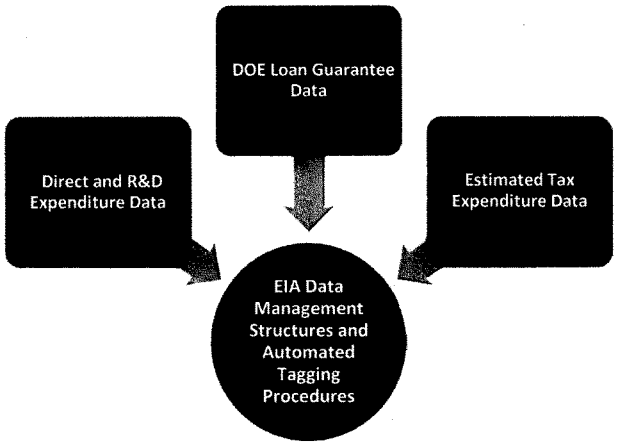
Figure 6. Data sources used for energy-related subsidies



[9] U.S. Energy Information Administration, Analysis and Projections: Subsidy, accessed February 16, 2018.

Budget terminology. Appropriations, obligations, and outlays are the primary phases of the U.S. government budget control system. Congress enacts appropriations that provide federal agencies and programs budget authority to make financial commitments (i.e., obligations) to spend funds. Obligations are legally binding agreements to purchase items or services, which is the budget phase captured in USASpending.gov. Outlays are actual payments made by the federal government for services performed, and they offset or liquidate outstanding obligations.

Figure 7. Relationship of data sources to EIA data processing



EIA uses the definitions of tax expenditures incorporated in federal budget documents and the associated tax expenditures estimated by the Treasury that are itemized in various sections of the Budget of the U.S. Government, *Analytical Perspectives*. To a lesser extent, this report includes data estimates by the congressional Joint Committee on Taxation. Some tax expenditures that benefit the energy industry may also support non-energy related activities, such as the use of accelerated depreciation schedules; these provisions are not included. EIA included only tax provisions that are narrowly targeted to the energy sector and were quantified by the other federal sources discussed here.

For direct expenditures, including research and development, EIA developed automated data processing when assigning energy-specific beneficiaries. For FY 2016 data, automated tagging or classification of nearly three million federal budgetary transactions were custom-designed, which in turn provided automated pre-binning and aggregation of more than 20,000 transactions meeting specified criteria for subsequent review by EIA's subject-matter experts.[10]

Obligation data come from a comprehensive public database summarizing all federal budget obligations; this transaction data is made available through USASpending.gov. In this report, as in the FY 2013 report

[10] USASpendng.gov is a database website owned by the U.S. Department of the Treasury that identifies entities or organizations receiving federal funds. It was created as part of the Federal Funding Accountability and Transparency Act (FFATA) of 2006.

update, direct expenditures and R&D expenditures for federal agencies other than DOE, Treasury, and the U.S. Department of Health and Human Services that administers LIHEAP come from USASpending.gov. These data represented about 10% (or $624 million) of the $6.2 billion estimated as the combined direct and R&D expenditures in energy subsidies in FY 2016. This smaller subset of subsidies underwent more extensive automated data processing, whereas the remaining 90% (or $5.6 billion) of the total was estimated directly from program office data sources listed in Figure 6.

Subsidy type exclusions. The definition of energy subsidy for this EIA report excludes federal staff and contractor actions. Some federal programs—such as National Laboratories—rely more extensively on contractor and staff work than others. As an example of a program with a large reliance on contracted work, the bulk of federal support to the nuclear energy industry is through direct federal program funding and not through grants and assistance awards. Funding is primarily through two organizations: the DOE and the Nuclear Regulatory Commission. The FY 2016 enacted appropriations for nuclear energy programs within DOE was $986 million.[11] Based on DOE's FY 2016 budget within the President's FY 2018 budget request, most nuclear energy-specific spending would support nuclear energy technology research and development programs, including fuel cycle, nuclear energy enabling technologies, small modular reactor licensing support, and management and operations at Idaho National Laboratory. These activities are not considered energy subsidies for purposes of this report.

DOE's direct expenditures and R&D expenditures are based on actual outlays, as provided by the Office of the Chief Financial Officer at DOE (Figure 6). Treasury's direct expenditures are similarly based on outlays, as obtained from the Office of Management and Budget's *Analytical Perspectives* report. As noted in earlier sections, appropriations, obligations, and outlays are the primary phases of the U.S. government budget control system.

Under steady-state conditions, where outlays follow obligations in a regular pattern and there are no sharp discontinuities in the former or the latter, obligation and outlay measures closely correspond. However, enactment of the Recovery Act of 2009, which included energy funding that dwarfed DOE's previous energy program budgets and required the rapid obligation of funds to cover outlays over several years, makes it more appropriate to report DOE programs based on outlays, using information obtained from DOE's Office of the Chief Financial Officer (Figure 1). This treatment is consistent with EIA's FY 2013 subsidy report update.

Data availability, accuracy, and variation

For measuring subsidies and support, EIA serves as a data aggregator from non-EIA federal data sources and depends on those federal sources for data quality and control issues. Tax expenditure estimates data are in most cases specific and accurate, as tax provisions included in this report typically are targeted to specific energy-related activities and are accounted for on a tax-year basis by Treasury. As a result, EIA staff could isolate numerous tax provisions and the corresponding energy system categories. Estimation procedures, however, were needed for a subset of tax expenditure data because particular tax provision data that could be made available, such as the specific types of renewable energy reported when a credit is taken, are not processed or published at this time. Improvements in the reporting on

[11] U.S. Department of Energy, FY 2018 Department of Energy's Budget Request to Congress, Nuclear Energy: Volume 3, page 531, accessed March 21, 2018.

these provisions would be beneficial. Such data are provided by taxpayers to the IRS when credits are claimed.

Each year Treasury estimates tax expenditures for the upcoming fiscal year budget. These appear in OMB's *Analytical Perspectives: Budget of the U.S. Government* report. Tax expenditure figures are estimates for historical FYs and forecasts for non-historical FYs. Prior-year tax expenditure estimates may be substantially revised. However, a particular year's revision will not necessarily affect all past estimates. The methodology Treasury uses to estimate tax expenditures is also subject to periodic modification, and these changes are not always applied to revisions of all historical tax expenditure data.

This report presents energy tax expenditure estimates for FYs 2010, 2013, and 2016. Sizable changes in the dollar value of particular expenditures over time often reflect changes in their utilization due to changes in the Internal Revenue Code (IRC), in key interpretations of the IRC, or in other relevant market and policy drivers. The historical data also reveal when particular energy programs were implemented and terminated, illustrating the magnitude of various tax policies affecting energy production and consumption over time. Although there are gaps in the data for some years, generalized trends in tax expenditures are still apparent. Some of the tax expenditure data presented in this report will be revised in the future, and some of the historical data presented here have not been fully revised.

Agencies are required to submit data files to USAspending.gov within 30 days after making an award or after making a modification or transaction to an award, except for the U.S. Department of Defense, which delays its submission by 90 days to protect operations. However, the timing of when specific records are displayed on USAspending.gov depends on when the agency submits files to the data source sites and the processing time required by that site. There could be a lag of one to three days before the files are processed and uploaded to USAspending.gov.

If an agency reports a modification or transaction to an award made in a previous fiscal year, the modification/transaction data are displayed in the fiscal year in which the modification/transaction was made, not in the fiscal year that the original award was made. EIA takes all fiscal year data as supplied regardless of these modifications.

Other energy subsidy studies

Debate continues over the scope, role, and effectiveness of energy policy measures, and several studies addressing energy subsidies appear each year from various sources and use different definitions and methods. Some examples within the past five years include: (1) Coady, Parry, Sears and Shang (2017), *How Large Are Global Fossil Fuel Subsidies?* in World Development; (2) National Renewable Energy Laboratory (2016), *Impacts of the Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions*; (3) Department of the Treasury, *Progress Report on Fossil Fuels Subsidies to G20*; and (4) Institute for Energy Research (2013), *Estimating the State-Level Impact of Federal Wind Energy Subsidies*. Several of these reports and others in the literature seek to draw conclusions about policy issues related to energy subsidies.

This EIA report focuses on developing data to provide information that can be used by others to conduct their own analyses. Along with EIA, the Congressional Research Service (CRS), the Congressional Budget Office (CBO), and the Government Accountability Office (GAO) also issue occasional reports on the

scope and nature of federal energy subsidies that mainly or exclusively focus on data. Recent CRS, CBO, and GAO reports include: (1) CRS (2017), *The Value of Energy Tax Incentives for Different Types of Energy Resources: In Brief*[12]; (2) CRS (2015), *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources*[13]; (3) CBO (2017), *Federal Support for Developing, Producing, and Using Fuels and Energy Technologies*; (4) GAO (2013), *Energy: Federal Support for Renewable and Advanced Energy Technologies*; and (5) GAO (2014), *Energy Policy: Information on Federal and Other Factors Influencing U.S. Energy Production and Consumption from 2000 through 2013*.

Taken together, the extensive literature on subsidies provides examples of how differing definitions and methods can yield a wide range of estimates and interpretations.

[12] CRS Report R44852, *The Value of Energy Tax Incentives for Different Types of Energy Resources: In Brief*, May 18, 2017, by Molly F. Sherlock.

[13] CRS Report R41953, *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources*, March 19, 2015, by Molly F. Sherlock and Jeffrey M. Stupak.

Tax Expenditures

In FY 2016, EIA estimates that U.S. federal energy-related tax expenditures were $8.8 billion, or 59% of the total subsidies and support identified in this report. This total is substantially lower than the $13.0 billion, or 44% share, in FY 2013. This decrease reflects, in large part, shifts in subsidies for renewable energy production over this period, including the installation of renewable energy production equipment on residential property. In addition, changes to tax expenditure estimates for oil- and natural gas-related activities for FY 2016 result in aggregate revenue inflows to Treasury, rather than subsidies to those industries (see Table).

Of the FY 2016 total tax expenditures ($8.8 billion) that subsidize or otherwise support activities of energy producers or consumers, $5.3 billion (60%) was for tax provisions that support renewable energy sources. End-use technologies represent the next largest source at $3.2 billion (36%), with coal being the next largest at $906 million (10%).

In preparing detailed data on energy-related tax expenditures (Table 5), EIA relied on the definitions of tax expenditures incorporated in the federal budget and the associated tax expenditures estimated by Treasury. To a lesser extent, this section includes data estimates by the congressional Joint Committee on Taxation (JCT). Tax expenditures arise from provisions in federal tax laws including credits, deductions, deferrals, preferential rates, and exemptions (exclusions). Items in the budget identified as tax expenditures by Treasury on occasion differ from those determined to be tax expenditures by the JCT. Historical tax expenditure data used in this report are taken from a number of government sources. For FY 2016, Treasury is the primary provider of estimates for tax expenditures, supplemented by data provided by the JCT.

Table 5. Estimates of energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Biodiesel Producer Tax Credit[a] (26 U.S.C. 6426)	539	1,667	2,650
Credit for Residential Energy Efficient Property (26 U.S.C. 25D)	242	1,000	1,450
Energy Production Credit (26 U.S.C. 45)	1,695	1,740	1,400
Energy Investment Credit (26 U.S.C. 48)	143	2,032	1,190
Alternative Fuel and Fuel Mixture Credit (26 U.S.C. 6426 and 6427e)	197	365	590
Tax Credit and Deduction for Clean-Burning Vehicles (26 U.S.C. 30, 30B, 30C, and 30D)	275	281	480
Exclusion from Income of Conservation Subsidies Provided by Public Utilities (26 U.S.C. 136)	242	354	430
Excess of Percentage over Cost Depletion (26 U.S.C. 611-613A and 291)	1,079	552	410
Amortization of Certain Pollution Control Facilities (26 U.S.C. 169)	110	417	500
Credit for Energy Efficiency Improvements to Existing Homes (26 U.S.C. 25C)	3,511	636	530
Credit for Construction of New Energy Efficient Homes (26 U.S.C. 45L)	22	156	210
Credit for Investment in Clean Coal Facilities (26 U.S.C. 48A, 48B)	264	188	160
Nuclear Decommissioning (26 U.S.C. 468A)	991	1,146	160
Capital Gains Treatment of Royalties on Coal (26 U.S.C. 631(c))	55	94	150
Natural Gas Distribution Pipelines being Treated as 15-Year Property (26 U.S.C. 168(e)(C)(iv))	132	104	140

Table 5. Estimates of energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Transmission Property Treated as Fifteen-Year Property (26 U.S.C. 168(e))	110	208	100
Allowance for the Deduction of Certain Energy Efficient Commercial Building Property(26 U.S.C. 179D)	66	73	80
Credit for Holding Clean Renewable Energy Bonds[b] (26 U.S.C. 54A and 54C)	77	73	70
Amortize All Geological and Geophysical Expenditures over 2 Years (26 U.S.C. 167(h))	165	104	70
Exception from Passive Loss Limitation for Working Interests in Oil and Gas Properties (26 U.S.C. 469)	33	21	60
Deferral of Gain from Disposition of Transmission Property to Implement FERC Restructuring Policy (26 U.S.C. 451(i))	(55)	-	60
Qualified Energy Conservation Bonds[c] (26 U.S.C. 54D)	-	21	30
Partial Expensing for Advanced Mine Safety Equipment (26 U.S.C. 179E)	3	28	24
Biodiesel and Small Agri-Biodiesel Producer Tax Credits (26 U.S.C. 6426)	22	21	30
Exclusion of Special Benefits for Disabled Coal Miners (26 U.S.C. 104, 30 U.S.C. 922)	43	31	30
Alcohol Fuel Credits (26 U.S.C. 6426)	77	42	10
Advanced Energy Manufacturing Facility Investment Tax Credit (26 U.S.C. 48C)	198	219	10
Expensing of Exploration and Development Costs (26 U.S.C. 263(c) and 291)	440	573	(450)
Temporary 50-Percent Expensing for Equipment used in the Refining of Liquid Fuels(26 U.S.C. 179C)	837	625	(1,760)
Alternative Fuel Production Credit (26 U.S.C. 45K)	187	10	-
Alcohol Fuel Exemption[a] (26 U.S.C. 6426)	6,252	10	-
Credit for Production from Advanced Nuclear Power Facilities (26 U.S.C. 45J(a))	-	-	-
Credit for Energy Efficient Appliances (26 U.S.C. 45M)	165	156	-
Mine Rescue Training Credit (26 U.S.C. 45N)	-	1	2
Expensing of Capital Goods with Respect to Complying with EPA Sulfur Regulations (26 U.S.C. 179B)	-	-	-
5-Year Net Operating Loss Carryover for Electric Transmission Equipment (26 U.S.C. 172)	-	-	-
Total	**18,119**	**12,951**	**8,816**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel and technology using data appearing in: https://energy.gov/articles/energy-department-announces-150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.

Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010).

[a]The alcohol fuel exemption (VEETC) is essentially the excise tax exemption equivalent to the alcohol fuel credits. The biodiesel producer tax credit is the excise tax exemption to the biodiesel and small agri-biodiesel producer tax credits. These are both listed as footnotes to OMB, *Analytical Perspectives*, tables which includes energy tax expenditures.

[b]In addition, the provision has an outlay effect of $10 million, $40 million, and $30 million in FY 2010, 2013, and 2016, respectively.

[c]In addition, the provision has an outlay effect of $30 million, $50 million, $40 million in FY 2010, 2013, and 2016, respectively.

In many cases, the level of energy production or investment determines the potential value of the tax expenditure for qualified taxpayers. However, the value of the tax expenditure received by eligible taxpayers may not equal the potential value of the expenditure based upon production or investment. One factor that mitigates against the eligible taxpayer receiving the full value of the tax expenditure is the alternative minimum tax (AMT), a separately calculated tax that eliminates many deductions and credits for which many tax expenditures are not exempt. Another mitigating factor is that the tax expenditure, in many cases, may not be received in the year in which the investment or production took place, but may, by law, be carried back or forward a number of tax years. Finally, most of the energy-related tax credits discussed in this report are not refundable; that is, the credit may not be claimed in excess of a taxpayer's tax liability (i.e., the credit cannot cause their tax burden to go negative). Therefore, a taxpayer with insufficient gross tax burden may be unable to fully claim a credit.

Treasury does not provide estimates of *de minimis* tax expenditures, i.e., $5 million or less. Therefore, the impact of such tax expenditures is not reported in either OMB budget documents or tabulations in this report.

Examples of energy-specific tax expenditures

The following examples illustrate the kinds of specific tax provisions associated with various categories of energy-related beneficiaries.

Coal. Table shows coal-related U.S. tax expenditures with an estimated value of $906 million in FY 2016, down from an estimated $811 million in FY 2013.

- **Amortization of Pollution Control Equipment (26 U.S.C. 169)**. EPAct 2005, Section 1309 modified Section 169 of the IRC, which permitted a 60-month amortization of qualifying pollution control facilities used in connection with plants placed in service before January 1, 1976. For plants placed in service after 1975, the EPAct 2005 modification provides that a taxpayer can recover the cost of any certified pollution control facility (but not a water pollution-control facility) over a period of 84 months for one placed in service after April 11, 2005, and used in connection with an electric generation plant or other property that is primarily coal-fired. The pre-existing 60-month amortization period remains in effect for any newly constructed certified air pollution control facility added at a plant in operation prior to January 1, 1976. The JCT estimated the value of this expenditure to be $417 million for FY 2013 and $500 million for FY 2016.
- **Credit for Investment in Clean Coal Facilities (26 U.S.C. 48A and 48B)**. This credit has an estimated value of $188 million in FY 2013 and $160 million in FY 2016. Section 1307 of the EPAct 2005 provided for a 20% credit to advanced coal projects using integrated gasification combined-cycle (IGCC) technology and a 15% credit to other advanced coal technologies. This legislation allocated $800 million tax credits towards electricity-related IGCC projects and $500 million towards other advanced coal technologies. An additional $350 million was applied to

coal gasification technologies for industrial use with an allowable tax credit of 20%. The Energy Improvement and Extension Act of 2008 (Public Law 111-343) authorized an additional $1.5 billion in tax credits for advanced coal and gasification projects, and it increased the investment tax credit for qualifying advanced coal and gasification projects to 30%.

Table 6. Estimates of coal-related energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Amortization of Certain Pollution Control Facilities	110	417	500
Credit for Investment in Clean Coal Facilities	264	188	160
Capital Gains Treatment of Royalties on Coal	55	94	150
Energy Production Credit	30	42	40
Exclusion of Special Benefits for Disabled Coal Miners	43	31	30
Partial Expensing for Advanced Mine Safety Equipment	3	28	24
Mine Rescue Training Credit	-	1	2
Advanced Energy Manufacturing Facility Investment Tax Credit	1	1	0
Subtotal Coal Tax Expenditures	**506**	**801**	**906**
Alternative Fuel Production Credit (Synthetic coal, coke and coke oven gas, and Steel Industry fuel)	187	10	-
Total	**693**	**811**	**906**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel using data appearing in: https://energy.gov/articles/energy-department-announces-150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.
Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1.

Renewable energy including biofuels. In FY 2013, 44% of energy-related U.S. tax expenditures were for renewable fuels. At $5.7 billion, renewable-related tax expenditures in FY 2013 were down 36% from $8.9 billion in FY 2010 (see Table). Ethanol and biodiesel both provide sizable volumes of the U.S. liquid fuels supply, and their market penetration has increased as the result of several policies that have resulted in significant income and excise tax expenditures. The excise tax policies had large fiscal impacts for the biodiesel industry. The biggest change for renewable energy since FY 2010 was attributed to the expiration of the alcohol fuel tax exemption, which received $6.3 billion in FY 2010 but has since decreased to zero. The biodiesel mixture credit increased from $1.7 billion in FY 2013 to $2.7 billion in FY 2016 as a result of greater domestic biomass-based diesel production and foreign imports of these products. Examples of renewable-related tax provisions include

- **Biodiesel Mixture Credit (26 U.S.C. 6426).** A tax credit was created by the American Jobs Creation Act of 2004 and later amended and extended various times. The biodiesel mixture credit–often referred to as the biodiesel blenders tax credit–had expired in previous years but Congress restored the credits retroactively. Qualified taxpayers may claim the biodiesel mixture credit, at $1.00 per gallon, when the applicable amount of biodiesel or renewable diesel is blended with petroleum diesel for sale or use in a trade or business. The credit is applied against the federal sales tax for diesel fuel imposed by 26 U.S.C. Section 4081. Biodiesel and renewable diesel blending activity was supported by EPA's Renewable Fuels Standard, which mandates the incorporation of biofuels into the nation's fuel supply, with biomass-based diesel final volume requirements in 2015 and 2016 of 1.73 and 1.90 billion gallons, respectively. Largely because of the renewable fuel standard (RFS), the fiscal impact increased from $1.7 billion in FY 2013 to $2.7 billion in FY 2016. The biodiesel mixture tax credit expired at the end of 2016 but was retroactively applied to 2017 as part of the Bipartisan Budget Act of 2018.
- **Production Tax Credit (26 U.S.C. 45)** The PTC is frequently referred to as the *Section 45 credit* for its applicable provision in the IRC.[14,15] It provides an inflation-adjusted tax credit worth 2.4 cents per kilowatthour (kWh) in 2016 to qualifying electricity production from wind energy facilities. It also provides a *half-value* credit of 1.2 cents per kWh for qualifying electricity production from closed-loop biomass, geothermal, solar, open-loop biomass, incremental hydroelectric, marine, tidal, and certain other waste energy facilities not claiming the Investment Tax Credit. The production tax credit for renewable resources is reported to have totaled $1.4 billion in FY 2016 versus $1.7 billion in FY 2013. Wind power was the primary beneficiary of this credit in FY 2016, which includes facilities built from 2006 through 2016. With enactment of ARRA, wind energy also became eligible for the investment tax credit (ITC). Because of the ability to exclusively claim one of these three subsidies during the FY 2010 and FY 2016 timeframe and because of the different temporal impacts of these provisions, it is not possible to accurately determine how much wind (or other similarly affected renewables) claimed the PTC or ITC for either year. EIA has generally assumed that wind energy projects will prefer the PTC over the ITC, and so assumed that those projects not taking the Section 1603 grant received the PTC instead.
- **The Energy Investment Tax Credit (26 U.S.C. 48).** The ITC, also referred to as the *Section 48 credit*, is the sole federal tax credit currently available to commercial solar facilities. It is also available as an alternative to the PTC discussed above. Originally established in the 1970s at a

[14] In the FY 2007 version of this report, the PTC was reported aggregated with the ITC as the "New Technology Credit", to be consistent with OMB reporting. However, current reporting separates these two business credits. EIA's FY 2010, FY 2013, and current report presents the PTC and ITC separately.

[15] Note that Section 45 of the Internal Revenue Code now contains several provisions that are accounted for elsewhere in this report. This report will reference only the renewable electricity production as the PTC.

value of 10%, the Energy Policy Act of 2005 (EPACT 05) temporarily increased the ITC value to 30% of capital costs and modified the expiration date for projects entering service by the end of 2019 and then ramped down to a value of 10% of capital cost for projects entering service by the end of 2022 and continued at the 10% level in perpetuity. The ITC is also known as a *business credit* and does not apply to projects owned by individuals. The credit for residential energy efficient property, also worth 30% of investment costs, was subsequently established for individual (residential) owners of solar and other end-use equipment. This latter credit reverted to zero at the end of 2016. ARRA expanded the scope of the ITC to include most renewable electricity technologies. However, EIA estimates that most of the more than $2.0 billion FY 2013 ITC tax expenditures went to solar and other end-use equipment and that other eligible renewables claimed either the PTC or the Section 1603 grant. This represents a 14-fold increase in expenditures for the ITC between FY 2010 and FY 2013.

Table 7. Estimates of renewable-related energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Biodiesel Producer Tax Credit[a]	539	1,667	2,650
Energy Production Credit	1,665	1,699	1,360
Energy Investment Credit	143	2,032	1,190
Credit for Holding Clean Renewable Energy Bonds[b]	77	73	70
Biodiesel and Small Agri-Biodiesel Producer Tax Credits	22	21	30
Alcohol Fuel Credits	77	42	10
Advanced Energy Manufacturing Facility Investment Tax Credit	138	139	6
Alternative Fuel Production Credit[c]	-	-	-
Alcohol Fuel Exemption[a]	6,252	10	-
Total	**8,913**	**5,683**	**5,316**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The credit for business installation of qualified fuel cells and microturbine power plants is part of the energy investment tax credit (Section 48 of the internal revenue code). The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel using data appearing in: https://energy.gov/articles/energy-department-announces-150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.

Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2018, 2015 and 2012. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1.

[a]The alcohol fuel exemption (VEETC) is essentially the excise tax exemption equivalent to the alcohol fuel credits. The biodiesel producer tax credit is the excise tax exemption to the biodiesel and small agri-biodiesel producer tax credits. These are both listed as footnotes in OMB's *Analytical Perspectives* tax expenditure tables, which includes energy tax expenditures.
[b]In addition, the provision has an outlay effect of $10 million, $40 million, and $30 million in FY 2010, FY 2013, and FY 2016, respectively.

[c]The alternative fuel production credit in FY 2010 and FY 2013 went primarily to coal.

Natural gas and petroleum. Natural gas and petroleum-related U.S. tax expenditures decreased from $2.3 billion in FY 2013 to an estimated revenue inflow (versus a positive tax expenditure) of $940 million in FY 2016 thus in aggregate becoming a set of revenue-generating tax provisions to the government in that fiscal year (Table).

- **The Temporary 50-Percent Expensing of Equipment Used in the Refining of Liquid Fuels (26 U.S.C. 179C)** Established under the Energy Policy Act of 2005, Section 1323, this provision is available for qualified refinery property used for processing liquid fuel from crude oil or qualified fuels and allows for an accelerated recovery of the cost of certain refinery investment under Section 179C of the IRC by allowing a partial expensing of the cost. It is estimated to have reached $625 million in FY 2013 to become a generating revenue item for the federal government with an estimated revenue of $1.8 billion in FY 2016.
- **The Expensing of Exploration and Development Costs (26 U.S.C. 263(c) and 291)** This provision allows energy producers, principally oil and natural gas producers, to expense exploration and development (E&D) expenditures (to include certain intangible drilling and development costs) rather than capitalize and depreciate them over time. The FY 2013 tax expenditure is estimated at $573 million. In FY 2016, this sector generated an estimated $450 million in revenues to the federal government.

Table 8. Estimates of natural gas- and petroleum-related energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Alternative Fuel and Fuel Mixture Credit	197	365	590
Excess of Percentage over Cost Depletion	1,079	552	410
Natural Gas Distribution Pipelines being Treated as 15-Year Property	132	104	140
Amortize All Geological and Geophysical Expenditures over 2 Years	165	104	70
Exception from Passive Loss Limitation for Working Interests in Oil and Gas Properties	33	21	60
Expensing of Exploration and Development Costs	440	573	(450)
Temporary 50-Percent Expensing for Equipment used in the Refining of Liquid Fuels	837	625	(1,760)
Expensing of Capital Goods with Respect to Complying with EPA Sulfur Regulations	-	-	-
Total	**2,883**	**2,345**	**(940)**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. A portion of the tax expenditures, but indeterminate amount, of the Excess of Percentage over Cost Depletion and the Expensing of exploration and Development Costs goes to coal.
Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax*

Expenditures for Fiscal Years 2012-2017, JCS-1-13 (Washington, DC, February 2013), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010)

Nuclear. The estimated expenditures for nuclear-related tax provisions fell from $1.2 billion in FY 2013 to $160 million in FY 2016 (Table). Nearly all of this decrease stems from the tax treatment of qualified and nonqualified nuclear decommissioning trust funds. Because these particular revisions to the Internal Revenue Code were not itemized by OMB for FY 2010 and FY 2013, EIA relied on the estimates of the value of these tax expenditures prepared by the JCT. A small portion of the advanced energy property tax credit was also directed to nuclear facilities. An example of these provisions is below:

- **The Modification to Special Rules for Nuclear Decommissioning Costs (26 U.S.C. 468A)**. Section 1310 of EPAct2005 changed the IRS rules for qualified nuclear decommissioning trust funds by repealing the cost of service requirement for contributions to a qualified decommissioning trust fund created under IRC Section 468A. This change permitted full present value funding of a qualified nuclear decommissioning fund and the transfer of pre-1984 decommissioning funds held in nonqualified trusts. The provision also required that nuclear plant owners obtain a new schedule of ruling amounts from the IRS upon renewal of a plant's operating license by the NRC. In FY 2016, EIA estimates the value of this tax expenditure was $160 million versus $1.2 billion in FY 2013. Modification of section 468A of the IRC was done to eliminate an impediment to nuclear plant sales arising from the structural change in the electric utility industry.

Table 9. Estimates of nuclear-related energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Nuclear Decommissioning	991	1,146	160
Advanced Energy Manufacturing Facility Investment Tax Credit	9	9	0
Credit for Production from Advanced Nuclear Power Facilities	-	-	-
Total	**999**	**1,155**	**160**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel using data appearing in: https://energy.gov/articles/energy-department-announces-150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.
Sources: **Tax expenditure estimates:** Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1.

Efficiency and conservation. The nine energy efficiency- and conservation-related tax provisions have collectively increased from $2.7 billion in FY 2013 to $3.2 billion in FY 2016, with the tax credit for

residential energy efficient property accounting for an expenditure increase of $0.5 billion (Table). Examples of these provisions include

- **Credit for Residential Energy Efficient Property (26 U.S.C. 25D)**. EIA estimates that this credit had a value of $1.5 billion in FY 2016 and $1.0 billion in FY 2013. Section 1335 of EPAct2005 established a 30% personal tax credit, not to exceed $2,000, for the purchase of solar electric and solar water heating property. A 30% tax credit up to $500 per 0.5 kilowatt (kW) of capacity is also available for fuel cells. The fuel cell provision of EPAct2005 was due to expire at the end of 2007. It was extended through the end of calendar year 2008 by Section 206 of the Tax Relief and Health Care Act of 2006 (Public Law 109-432). Section 106 of EIEA2007 removed the cap on the tax credit for purchase of residential solar photovoltaic installations and extended the credit to December 31, 2016. Section 104 of EIEA extended the credit to include small wind properties (under 100 kilowatts) through December 31, 2016; and, Section 105 extended the tax credit to include geothermal heat pumps through December 31, 2016. Finally, Section 1122 of ARRA removed some of the previous maximum amounts and allowed a credit equal to 30% of the cost of qualified property.
- **Credit for Energy Efficiency Improvements to Existing Homes (26 U.S.C 25C)**. This credit was established in EPAct2005, Section 1333, and it is estimated at a value of $530 million in FY 2016, down from an estimated $636 million in FY 2013 with most of this decrease traceable to the higher credit amounts made available due to ARRA. This credit applies to windows, furnaces, boilers, furnace fans, and building envelope components, such as exterior doors and any metal roof that has appropriate pigmented coatings.

Table 10. Estimates of conservation, efficiency, and end-use energy-specific tax expenditures, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Credit for Residential Energy Efficient Property	242	1,000	1,450
Credit for Energy Efficiency Improvements to Existing Homes	3,511	636	530
Tax Credit and Deduction for Clean-Burning Vehicles	275	281	480
Exclusion from Income of Conservation Subsidies Provided by Public Utilities	242	354	430
Credit for Construction of New Energy Efficient Homes	22	156	210
Allowance for the Deduction of Certain Energy Efficient Commercial Building Property	66	73	80
Qualified Energy Conservation Bonds	-	21	30
Advanced Energy Manufacturing Facility Investment Tax Credit	43	59	3
Credit for Energy Efficient Appliances	165	156	-
Total	**4,567**	**2,737**	**3,213**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel using data appearing in: https://energy.gov/articles/energy-department-

announces-150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.
Sources: **Tax expenditure estimates:** Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2012, 2015 and 2018. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1.

Electricity transmission and grid network. Transmission-related tax expenditures fell from $219 million in FY 2013 to $160 million in FY 2016 (Table). This decrease is largely a result of the decrease in estimated expenditures from transmission property treated as 15-year property, which fell by more than half from FY 2013 to FY 2016. Examples of these provisions include

- **The Transmission Property Treated as 15-year Property (26 U.S.C. 168(e))**. This permanent provision was set forth in Section 1308 of EPAct2005 and modified Section 168 of the IRC by shortening the recovery period for specified assets from 20 to 15 years. To be eligible, an asset must be used in the transmission of electricity following sale of the property or related land improvements. Specifically, this applies to Section 1245 property, (i.e., personal property and real property subject to depreciation or amortization) used in the transmission of electricity that is energized at 69 kilovolts or more. The provision applies to transmission facilities placed in service by the taxpayer after April 11, 2005, but excludes any transmission facilities for which the taxpayer or related party had entered into a binding construction contract for or initiated self-construction on or before April 11, 2005. This tax provision is permanent, under current statutes.[16] For FY 2016, the estimated value of accelerating the standard recovery period by five years is $100 million, down from $208 million in FY 2013.

Table 11. Estimates of electricity transmission-related energy-specific tax expenditure, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Tax Provision	FY 2010	FY 2013	FY 2016
Transmission Property Treated as Fifteen-Year Property	110	208	100
Deferral of Gain from Disposition of Transmission Property to Implement FERC Restructuring Policy	(55)	-	60
Advanced Energy Manufacturing Facility Investment Tax Credit	8	11	0
5-Year Net Operating Loss Carryover for Electric Transmission Equipment	-	-	-
Total	**63**	**219**	**160**

Note: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. The advanced energy manufacturing facility investment tax credit or sometimes called advanced energy property credit was allocated by fuel using data appearing in: https://energy.gov/articles/energy-department-announces-

[16] Joint Committee on Taxation, *Report to the House Committee on Ways and Means on Present Law and Suggestions for Reform, Tax Reform Working Groups submissions*, JCS-3-13, May 6, 2013.

150-million-tax-credits-invest-us-clean-energy-manufacturing (Phase II of Section 48C) and IRC Section 48C Certifications at https://www.irs.gov/businesses/irc-section-48c-certifications, accessed March 20, 2018.
Sources: **Tax expenditure estimates**: Office of Management and Budget, *Analytical Perspectives, Budget of the U.S. Government*, Fiscal Years 2018, 2015 and 2012. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2016-2020*, JCX-3-17 (Washington, DC, January 2017), Table 1, Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2012-2017*, JCS-1-13 (Washington, DC, February 2013), Table 1, and Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2010-2014*, JCS-3-10 (Washington, DC, December 2010), Table 1.

Direct Expenditures, Including R&D

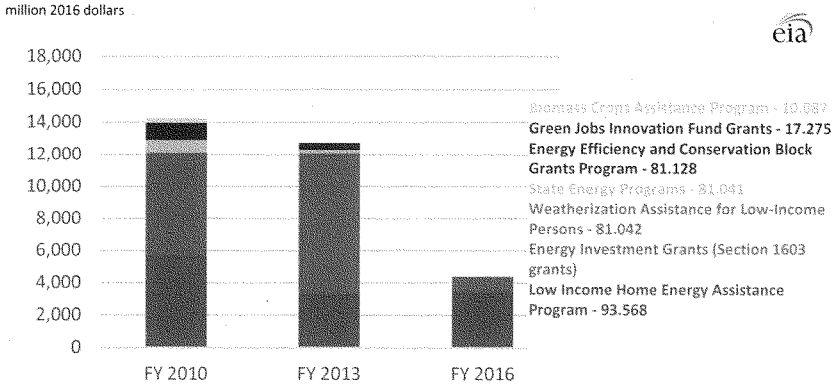
Direct expenditures, in contrast to tax expenditures, involve the transfer of congressionally appropriated funds to recipients by federal agencies. The enormous volume and diversity of federal direct expenditures makes it very difficult to assign energy-related activities to specific aspects of the energy system. As discussed in the Analytic Approach section, EIA has developed several powerful methods of obtaining and processing federal expenditure data; the resulting estimates in this section are nonetheless subject to scope and measurement issues.

This section follows the outline of the previous section, but adds information on agency-specific activities to the energy-specific discussions.

Table 12 shows the most comprehensive picture of the direct expenditure amounts estimated for each part of the energy system. As described in the Analytic Approach section, the Catalog of Federal Direct Assistance (CFDA) is the primary source for program information as well as CFDA coding for both agency and program designations.

Renewable energy facility construction (the Energy Investment Grant) and low-income energy assistance (LIHEAP, energy efficiency block grants, and weatherization) have dominated direct expenditures for energy over the three FY periods displayed in this report. Direct expenditures in these two areas accounted for nearly 67% of the FY 2010 total, with their percentage rising to 89% in FY 2016 (see Figure 8). Of more than 35 direct expenditure programs in Table 12, 7 programs accounted for between 92% and 95% of the total direct expenditures over the three FY time periods of interest in this report.

Figure 8. Direct expenditures by select programs, FY 2010, FY 2013, and FY 2016



Source: Table 12.

Tables in this section summarize the energy-specific categories with respect to the total set of direct expenditures in Table 12 and also sort by the 15 energy-specific categories.

Textbox: Federal direct purchasing of designated energy products

A set of overlapping federal programs aimed at direct acquisition of renewable, sustainable, resilient, or other designated energy resources has seen rapid growth in recent years. Driven in part by statute and Executive Orders, these programs allow or require federal organizations to use certain energy resource acquisition procedures, sometimes on a pooled or regional basis.

The definition of direct federal financial interventions (or subsidies) used in this report would generally only include federal energy purchases that add incremental cost and are intended to provide market support for the purchased resource. Because federal acquisition programs pursue a wide variety of goals—both operational and policy-related—such a determination is often difficult to make. To date, EIA has not included federal energy acquisition programs in the report tables or summaries.

Without determining what portion of these activities might be considered subsidies or market interventions, data from federal programs, both Defense and non-Defense, indicate the magnitude of direct energy acquisition activities in FY 2016.

Defense. The Department of Defense FY 2016 Operational Energy Annual Report includes accounting for more than $46 billion in Defense-related energy purchasing in FY 2016. Of this, slightly more than $1.8 billion is considered to be Operational Energy Initiatives that encompass a wide variety of activities. Research and development, field testing, pilot deployments, energy-reducing measures, and purchases of specific fuels (typically renewable energy sources) are all included.

Non-Defense. The Federal Energy Management Program (FEMP) and the General Services Administration (GSA) are responsible for most non-defense federal energy acquisition activities. Much of this activity is related to the March 2015 Executive Order on federal facility sustainability planning, which is summarized in a DOE progress report.

Table 12. Estimates of direct expenditures in energy, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**364**	**139**	**97**
Rural Energy for America Program - 10.868	55	45	35
Biofuel Infrastructure Partnership - 10.117	-	-	15
Bioenergy Program for Advanced Biofuels - 10.867	21	49	14
Biomass Crop Assistance Program - 10.087	269	9	10
Denali Commission Program - 90.100	-	16	8
Assistance to High Energy Cost Rural Communities - 10.859	8	14	6
Sun Grant Program - 10.320	2	2	5
Wood Utilization Assistance - 10.674	5	3	3
Biodiesel (Biodiesel Fuel Education Program) - 10.306	1	(0)	1
Biorefinery Assistance - 10.865	-	-	-
State Bulk Fuel Revolving Fund Grants - 10.857	1	-	-
Forest Biomass for Energy - 10.686	-	-	-
Repowering Assistance - 10.866	2	-	-
Community Wood Energy Program - 10.685	-	-	-
U.S. Department of Energy	**3,577**	**1,421**	**304**
Weatherization Assistance for Low-Income Persons - 81.042	1,818	313	182
State Energy Program - 81.041	784	212	46
Energy Efficiency and Renewable Energy Information Dissemination, Outreach, Training and Technical Analysis/Assistance - 81.117	42	47	31
Epidemiology and Other Health Studies Financial Assistance Program - 81.108	1	13	14
Expand and Extend Clean Coal Power Initiative - 81.131	46	52	11
State Energy Program Special Projects - 81.119	9	11	7
Nuclear Waste Disposal Siting - 81.065	9	5	6
Transport of Transuranic Wastes to the Waste Isolation Pilot Plant: States and Tribal Concerns, Proposed Solutions - 81.106	40	5	4
Industrial Carbon Capture and Storage (CCS) Application - 81.134	62	298	3
Carbon Capture and Storage-FutureGen 2.0 - 81.130	-	24	1
State Heating Oil and Propane Program - 81.138	-	0	0
Energy Efficiency and Renewable Energy Technology Deployment, Demonstration and Commercialization - 81.129	3	1	-
National Industrial Competitiveness through Energy, Environment, and Economics - 81.105	0	-	-
Geologic Sequestration Site Characterization - 81.132	-	-	-
Energy Efficiency and Conservation Block Grant Program (EECBG) - 81.128	549	436	-
Energy Efficient Appliance Rebate Program (EEARP) - 81.127	214	(0)	-
Office of Scientific and Technical Information - 81.064	-	-	-
Regional Biomass Energy Programs - 81.079	1	1	-
Inventions and Innovations - 81.036	0	2	-
U.S. Department of Health and Human Services	**5,614**	**3,247**	**3,368**
Low Income Home Energy Assistance - 93.568	5,614	3,247	3,368

Table 12. Estimates of direct expenditures in energy, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Housing and Urban Development	**259**	**-**	**(2)**
Assisted Housing Stability and Energy and Green Retrofit Investments Program - 14.318	259	-	-
Multifamily Energy Innovation Fund - 14.319	-	-	(2)
U.S. Department of Labor	**499**	**(2)**	**(0)**
Green Jobs Innovation Fund Grants - 17.275	499	(2)	(0)
U.S. Department of State	**-**	**-**	**-**
Bureau of Western Hemisphere Affairs (WHA) Grant Programs (including Energy and Climate Partnership for the Americas) - 19.750	-	-	-
U.S. Department of the Interior	**12**	**9**	**28**
Federal Oil and Gas Royalty Management State and Tribal Coordination - 15.427	-	-	12
Science and Technology Projects Related to Coal Mining and Reclamation - 15.255	-	(0)	7
BOEM Environmental Studies Program - 15.423	0	4	5
Minerals and Mining on Indian Lands - 15.038	10	3	3
Louisiana State University (LSU) Coastal Marine Institute CMI - 15.422	1	1	1
Energy Cooperatives to Support the National Coal Resources Data System (NCRDS) - 15.819	0	0	0
Tribal Energy Development Capacity Grants - 15.148	-	-	-
U.S. Department of Transportation	**272**	**88**	**42**
Pipeline Safety Program State Base Grant - 20.700	43	46	40
PHMSA Pipeline Safety Program One Call Grant - 20.721	1	1	1
Air Emissions and Energy Initiative - 20.817	-	1	0
Railroad Research and Development - 20.313	-	-	-
Capital Assistance Program for Reducing Energy Consumption and Greenhouse Gas Emissions - 20.523	216	15	-
Clean Fuels - 20.519	12	24	-
U.S. Department of the Treasury	**4,678**	**8,514**	**820**
Energy Investment Grant; Outlay Equivalent for Clean Renewable Energy Bonds; Outlay Equivalent for Qualified Energy Conservation Bonds	4,678	8,514	820
U.S. Environmental Protection Agency	**134**	**18**	**45**
National Clean Diesel Emissions Reduction Program - 66.039	101	14	33
State Clean Diesel Grant Program - 66.040	32	5	12
Nuclear Regulatory Commission	**19**	**16**	**16**
U.S. Nuclear Regulatory Commission Scholarship and Fellowship Program - 77.008	12	15	15
U.S. Nuclear Regulatory Commission Minority Serving Institutions Program (MISP) - 77.007	2	1	1
U.S. Nuclear Regulatory Commission Nuclear Education Grant Program - 77.006	6	-	(0)
Total	**15,427**	**13,450**	**4,716**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. Energy investment grants are commonly referred to as Section 1603 grants administered by the U.S. Department of the Treasury.

Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; U.S. Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov*, website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 13. Estimates of research and development expenditures in energy, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**34**	**4**	**11**
Biomass Research and Development Initiative Competitive Grants Program (BRDI) - 10.312	32	(2)	7
Agricultural Research Basic and Applied Research - 10.001	2	6	5
U.S. Department of Defense	**22**	**5**	**52**
Basic Scientific Research - 12.431	7	4	46
Basic, Applied, and Advanced Research in Science and Engineering - 12.630	6	1	7
Research and Technology Development - 12.910	8	0	0
U.S. Department of Energy	**2,244**	**2,284**	**1,051**
Fossil Energy Research and Development - 81.089	321	218	377
Renewable Energy Research and Development - 81.087	610	501	184
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	29	149	184
Conservation Research and Development - 81.086	587	454	151
Nuclear Energy Research, Development and Demonstration - 81.121	174	133	137
Electricity Delivery and Energy Reliability, Research, Development and Analysis - 81.122	518	824	15
University Coal Research - 81.057	2	2	2
Geologic Sequestration Training and Research Grant Program - 81.133	3	4	-
U.S. Department of the Interior	**1**	**0**	**2**
Safety and Environmental Enforcement Research and Data Collection for Offshore Energy and Mineral Activities - 15.441	-	-	2
Offshore Research Technology Center (OTRC) Texas Engineering Experiment Station (TEES) - 15.425	-	-	-
Marine Gas Hydrate Research Activities - 15.428	1	0	(0)
U.S. Department of Transportation	**6**	**16**	**2**
PHMSA Pipeline Safety Research and Development Other Transaction Agreements - 20.723	6	16	2
Biobased Transportation Research - 20.761	0	-	-
Hydrogen Storage Research and Development - 20.764	-	-	-
U.S. Environmental Protection Agency	**3**	**3**	**2**
Surveys, Studies, Research, Investigations, Demonstrations, and Special Purpose Activities Relating to the Clean Air Act - 66.034	3	3	2

Table 13. Estimates of research and development expenditures in energy, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
National Science Foundation	**407**	**621**	**328**
Mathematical and Physical Sciences - 47.049	268	475	243
Engineering Grants - 47.041	138	146	86
Nuclear Regulatory Commission	2	0	2
U.S. Nuclear Regulatory Commission Office of Research Financial Assistance Program - 77.009	2	0	2
Total	**2,718**	**2,934**	**1,451**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.

Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Examples of energy-specific direct expenditure and R&D programs

Coal. Direct expenditures for coal-related programs decreased from $77 million in FY 2013 to $19 million in FY 2016, while R&D spending rose from $216 million in FY 2013 to $337 million in FY 2016. Table and Table show detailed coal-related program outlays. Examples of coal-related federal activities include

- **Carbon Capture and Sequestration (CCS).** DOE's Fossil Energy Research and Development program portfolio includes CCS technology research. Coal-centered CCS focuses on post-combustion capture of carbon dioxide (CO2) from existing plants and industrial sources. Sequestration research aims to provide reliable and safe permanent storage of CO2 gas to mitigate carbon emission for fossil fuel sources. In 2016, DOE's R&D expenditures also supported the FutureGen 2.0 project, an oxy-fuel retrofit of a recently idled 65-year-old facility in Illinois. FutureGen 2.0 was a DOE CCS demonstration project, combining all three aspects of CCS technology: capturing and separating CO2 from other gases, compressing and transporting CO2 to the sequestration site, and injecting CO2 in geologic formations for permanent storage.
- **University Coal Research (UCR).** UCR supports hands-on research experience to future generations of scientists and engineers. Since the program's inception in 1980, more than $100 million has been provided and more than 1,700 students have acquired experience in understanding the science and technology of coal. UCR projects include a number of diverse coal-based studies. In FY 2016, UCR supported projects researching high-tech sensors and

controls, water management and flue gas desulfurization, and the use of high-performance materials in steam turbines.

Table 14. Estimates of coal-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S Department of Energy	**46**	**77**	**12**
Expand and Extend Clean Coal Power Initiative - 81.131	46	52	11
Carbon Capture and Storage-FutureGen 2.0 - 81.130	-	24	1
U.S. Department of the Interior	**2**	**1**	**7**
Science and Technology Projects Related to Coal Mining and Reclamation - 15.255	-	(0)	7
Minerals and Mining on Indian Lands - 15.038	1	0	0
Energy Cooperatives to Support the National Coal Resources Data System (NCRDS) - 15.819	0	0	0
Total	**48**	**77**	**19**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 15. Estimates of coal-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Energy	**320**	**211**	**335**
Fossil Energy Research and Development - 81.089	318	207	333
University Coal Research - 81.057	2	2	2
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	1	2	-
National Science Foundation	**-**	**5**	**2**
Mathematical and Physical Sciences - 47.049	-	5	2
Total	**320**	**216**	**337**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16,

2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Renewable energy including biofuels. Renewable energy direct expenditures have varied considerably, dropping to $909 million in FY 2016 from $8.7 billion in FY 2013. In each fiscal year, however, the overwhelming share of renewable energy direct expenditures came from an ARRA modification of two tax expenditure provisions previously discussed:

- The PTC, where the support amount is based on electricity generation from eligible new renewable electricity facilities
- Two tax credit bonds, the clean renewable energy bond (CREB) and the qualified energy conservation bond (QECB) for public-sector renewable projects

Table 16. Estimates of renewable-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**322**	**95**	**82**
Rural Energy for America Program - 10.868	19	25	32
Biofuel Infrastructure Partnership - 10.117	-	-	15
Bioenergy Program for Advanced Biofuels - 10.867	21	49	14
Biomass Crop Assistance Program - 10.087	269	9	10
Sun Grant Program - 10.320	2	2	5
Wood Utilization Assistance - 10.674	5	3	3
Assistance to High Energy Cost Rural Communities - 10.859	4	5	2
Biodiesel (Biodiesel Fuel Education Program) - 10.306	1	(0)	1
Repowering Assistance - 10.866	2	-	-
Denali Commission Program - 90.100	-	1	-
Forest Biomass for Energy - 10.686	-	-	-
Biorefinery Assistance - 10.865	-	-	-
Community Wood Energy Program - 10.685	-	-	-
U.S. Department of Energy	**288**	**98**	**4**
Energy Efficiency and Renewable Energy Information Dissemination, Outreach, Training and Technical Analysis/Assistance - 81.117	23	25	2
State Energy Program - 81.041	262	71	1
Regional Biomass Energy Programs - 81.079	1	1	-
Office of Scientific and Technical Information - 81.064	-	-	-
Energy Efficiency and Renewable Energy Technology Deployment, Demonstration and Commercialization - 81.129	2	0	-
Industrial Carbon Capture and Storage (CCS) Application - 81.134	1	-	-
Inventions and Innovations - 81.036	0	1	-

Table 16. Estimates of renewable-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Labor	**437**	**(2)**	**(0)**
Green Jobs Innovation Fund Grants - 17.275	437	(2)	(0)
U.S. Department of the Interior	**3**	**2**	**3**
Minerals and Mining on Indian Lands - 15.038	3	1	3
BOEM Environmental Studies Program - 15.423	-	0	1
Tribal Energy Development Capacity Grants - 15.148	-	-	-
U.S. Department of Transportation	**4**	**10**	**0**
Air Emissions and Energy Initiative - 20.817	-	1	0
Clean Fuels - 20.519	4	8	-
U.S. Department of the Treasury	**4,678**	**8,514**	**820**
Energy Investment Grant; Outlay Equivalent for Clean Renewable Energy Bonds; Outlay Equivalent for Qualified Energy Conservation Bonds	4,678	8,514	820
U.S. Environmental Protection Agency	**-**	**-**	**0**
State Clean Diesel Grant Program - 66.040	-	-	0
Total	**5,732**	**8,716**	**909**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov*, website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Congress created direct expenditure programs related to each of these after the 2008 recession. At that time, few companies interested in constructing projects that would qualify for the PTC, CREBs, or QECBs had sufficient tax liability to offset those programs' tax credits.[17] To maintain support for building new renewable energy facilities, Congress created direct payment programs that entities could opt for in lieu of the tax credits. It is important to note that Treasury does not regard these two direct expenditure programs as *domestic financial assistance*, so they do not appear in the CFDA. Each program is discussed below:

- **Energy investment grants** (Section 1603 of Public Law 111-5) Congress created Energy Investment Grants as an alternative support program to the PTC. The program was created as a part of ARRA, which authorized Treasury to provide grants up to 30% of PTC-eligible facility

[17] Many firms during and after the 2008-09 recession were making little or no profit, so they owed little or no tax. Under such conditions, a firm's eligible PTC tax credit exceeded its total tax liability, greatly limiting the amount of the tax credit it could claim.

construction costs.[18] Taking a grant instead of the PTC eliminates dependence on tax liability considerations. Because the grants are largely tied to PTC-eligible facilities, direct expenditures for Section 1603 grants have declined sharply between FY 2013 and FY 2016 as the PTC or 1603 grant deadline expired for some types of renewable energy-producing facilities. Energy investment grants fell sharply from previous years. No additional projects are expected to receive the Section 1603 grants.

- **Payments in lieu of tax credits for CREBs and QECBs** (Public Law 111-147)**.** In March 2010, Congress enacted Public Law 111-147 (Section 301), permitting new CREB and QECB issuers (in the public sector) to make an irrevocable election to receive a direct payment—a refundable tax credit—from Treasury. The amount is equivalent to, and in lieu of, the amount of the non-refundable tax credit that would otherwise be provided to the bondholder.[19] New CREBs are those issued after March 18, 2010, the enactment date of the law. In April 2010, the Internal Revenue Service issued Notice 2010-35 that provides guidance on the direct payment option.[20] As a result of the Tax Cuts and Jobs Act being signed into law on December 22, 2017, new CREBs have been eliminated effective January 1, 2018.

Table 17. Estimates of renewable-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**34**	**4**	**8**
Biomass Research and Development Initiative Competitive Grants Program (BRDI) - 10.312	32	(2)	7
Agricultural Research Basic and Applied Research - 10.001	2	6	1
U.S. Department of Defense	**22**	**5**	**2**
Basic Scientific Research - 12.431	7	4	2
Research and Technology Development - 12.910	8	0	0
Basic, Applied, and Advanced Research in Science and Engineering - 12.630	6	1	-
U.S. Department of Energy	**551**	**488**	**233**
Renewable Energy Research and Development - 81.087	542	445	166
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	9	43	60
Fossil Energy Research and Development - 81.089	-	-	6
Department of Transportation	0	-	-
Biobased Transportation Research - 20.761	0	-	-

[18] In addition to PTC-eligible facilities, certain energy efficiency investments (e.g., LED lighting) are also eligible for the grants.
[19] For more details, see the Database for State Incentives for Renewables and Efficiency (DSIRE). DSIRE also includes information on federal and state renewable energy incentive programs.
[20] Public Law 111-147 also created direct expenditure provisions for other Tax Credit Bonds.

Table 17. Estimates of renewable-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Environmental Protection Agency	**0**	**0**	**-**
Surveys, Studies, Research, Investigations, Demonstrations, and Special Purpose Activities Relating to the Clean Air Act - 66.034	0	0	-
National Science Foundation	**237**	**367**	**214**
Mathematical and Physical Sciences - 47.049	156	276	169
Engineering Grants - 47.041	81	90	45
Total	**844**	**864**	**456**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.

Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; U.S. Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Renewable energy R&D. More than 90% of federal renewable energy R&D support came from DOE and the National Science Foundation (NSF) in all fiscal years.

Federal spending on renewable energy R&D dropped by nearly 50% between FY 2013 and FY 2016. A $255 million reduction in DOE's principal renewable energy R&D program, although spending increased on early-stage research by DOE's Advanced Research Projects Agency.

The principal NSF program funding renewable energy R&D in FY 2016 was the physical sciences.

Physical science grants tend to address research at earlier stages than engineering grants (see *Textbox: Research and development for general application* at the end of this section). More than 70% of physical science grants went to solar energy research with virtually all of the remainder for *other renewable energy* (e.g., fuel cells). Engineering grants, which totaled slightly more than one-fifth of physical science grants, also principally funded solar energy research (56%).

Major federal R&D programs for renewable energy are discussed below:

- **Renewable Energy Research and Development** (81.087). This R&D program is DOE's largest renewable-related R&D program (note that DOE's Office of Science programs are being treated as non-specific, as discussed in *Textbox: Research and development for general application* at the end of this section) and administers grants in the areas of solar, biomass, hydrogen fuel cells

and infrastructure, wind and hydropower, and geothermal.[21] Projects in fuel areas except for biomass are exclusively related to electricity generation. Biomass projects also include biofuels research and related fuel-vehicle research. The largest category of award recipients in FY 2016 was colleges and universities, which received more than one-third of all awards. Solar and wind have received most of the grant money for electricity projects over the years with solar receiving the largest share in FY 2016.

- **Energy Efficiency and Renewable Energy Information Dissemination, Outreach, Training and Technical Analysis/Assistance** (81.117). This program is the longest-running direct assistance energy program, established by the Energy Reorganization Act of 1974 (Public Law 93-438). As its name suggests, this program funds both energy efficiency and renewable energy projects. Within renewable energy, the program has a broad focus, including all forms of renewable energy use and production. Specifically, it provides financial assistance for information dissemination, outreach, training, and related technical analysis designed to encourage increased use of renewable and alternative energy and accelerate the adoption of new technologies to increase the use of renewable and alternative energy through the competitive solicitation of applications. More than half of FY 2016 awards supported Industrial Assessment Centers (IACs), whose primary goal is to train the next generation of energy engineers. IACs also offer feasibility studies to qualified plants to significantly improve their energy efficiency and promote renewable energy. This program also supports the Database for State Incentives on Renewable Energy (DSIRE),[22] a website containing comprehensive information about incentives for renewable energy.
- **National Science Foundation** (47.041 and 47.049). NSF implements two research programs that include sizable grant awards for energy research. Engineering grants provide engineering knowledge, education, and knowledge transfer to the broader population. However, only a fraction of engineering energy-related awards are oriented to specific fuel areas covered in this report. The most common renewable fuel studied in FY 2016 engineering grants was solar energy. Renewable projects range from basic engineering theory to studying engineering improvements for commercial projects and processes. The other major NSF energy project covers mathematics and physical sciences.

Petroleum and natural gas. Table shows petroleum and natural gas-related federal direct expenditures while Table shows associated R&D outlays. Petroleum and natural gas-related direct expenditures, including R&D, would have been fairly stable except for the $298 million entry in FY 2013 for the Industrial Carbon Capture and Storage program from the Department of Energy. In FY 2016, the National

[21] Hydropower includes conventional hydropower as well as ocean energy (e.g., wave, tidal, etc.).
[22] DSIRE also includes information about Federal renewable energy incentives.

Clean Diesel Emissions Reduction Program increased to $33 million from $14 million in FY 2013. Other elements in this area, in aggregate, saw funding decrease slightly from FY 2013 ($140 million) to FY 2016 ($134 million). One example of an oil and natural gas-related direct expenditure program is

- **The Bureau of Ocean Energy Management (BOEM) Environmental Studies Program (ESP).** The mission of the ESP is to enable the Department of the Interior (DOI) to perform its environmental stewardship duties by producing scientific research aimed at safer ocean-based energy production. The ESP is a strategic planning program and plans annual activities through a Study Development Plan. The National Academy of Sciences Committee on Offshore Science and Assessment (COSA) advises ESP on the scientific and technical aspects of the proposed study efforts. According to BOEM, the ESP budget is balanced annually and tracked to its ultimate use. When a study is complete, BOEM measures success and accountability with an OMB tool – the Environmental Studies Program Assessment Tool.

Table 18. Estimates of natural gas- and petroleum-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**1**	**11**	**6**
Denali Commission Program - 90.100	-	11	6
State Bulk Fuel Revolving Fund Grants - 10.857	1	-	-
U.S. Department of Energy	**-**	**298**	**3**
Industrial Carbon Capture and Storage (CCS) Application - 81.134	-	298	3
State Heating Oil and Propane Program - 81.138	-	0	0
Geologic Sequestration Site Characterization - 81.132	-	-	-
Inventions and Innovations - 81.036	-	-	-
U.S. Department of the Interior	**2**	**5**	**17**
Federal Oil and Gas Royalty Management State and Tribal Coordination - 15.427	-	-	12
BOEM Environmental Studies Program - 15.423	0	4	4
Louisiana State University (LSU) Coastal Marine Institute CMI - 15.422	1	1	1
Minerals and Mining on Indian Lands - 15.038	-	-	0
U.S. Department of Transportation	**48**	**55**	**42**
Pipeline Safety Program State Base Grant - 20.700	43	46	40
PHMSA Pipeline Safety Program One Call Grant - 20.721	1	1	1
Clean Fuels - 20.519	4	8	-
U.S. Environmental Protection Agency	**32**	**18**	**44**
National Clean Diesel Emissions Reduction Program - 66.039	-	14	33
State Clean Diesel Grant Program - 66.040	32	5	12
Total	**83**	**388**	**111**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 19. Estimates of natural gas- and petroleum-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Defense	**-**	**-**	**1**
Basic Scientific Research - 12.431	-	-	1
Basic, Applied, and Advanced Research in Science and Engineering - 12.630	-	-	0
U.S. Department of Energy	**3**	**22**	**42**
Fossil Energy Research and Development - 81.089	3	11	38
Conservation Research and Development - 81.086	-	-	5
Geologic Sequestration Training and Research Grant Program - 81.133	-	4	-
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	0	8	-
U.S. Department of the Interior	**1**	**0**	**2**
Safety and Environmental Enforcement Research and Data Collection for Offshore Energy and Mineral Activities - 15.441	-	-	2
Offshore Research Technology Center (OTRC) Texas Engineering Experiment Station (TEES) - 15.425	-	-	-
Marine Gas Hydrate Research Activities - 15.428	1	0	(0)
U.S. Department of Transportation	**6**	**16**	**2**
PHMSA Pipeline Safety Research and Development Other Transaction Agreements - 20.723	6	16	2
National Science Foundation	**-**	**25**	**8**
Engineering Grants - 47.041	-	-	6
Mathematical and Physical Sciences - 47.049	-	25	2
Total	**10**	**64**	**56**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Nuclear. Nuclear direct expenditures, inclusive of R&D, have decreased from $235 million in FY 2013 to $204 million in FY 2016. These activities are dominated by DOE program efforts. Unlike most kinds of federal energy assistance, nuclear support is higher in R&D than in direct expenditures. Note that some DOE R&D is not categorized by energy system category, as discussed in the *Textbox: Research and development for general application* at the end of this section; some of this basic R&D is also presumably used by the nuclear energy industry, as well as by others.

Table 20. Estimates of nuclear transformation-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Energy	**50**	**23**	**25**
Epidemiology and Other Health Studies Financial Assistance Program - 81.108	1	13	14
Nuclear Waste Disposal Siting - 81.065	9	5	6
Transport of Transuranic Wastes to the Waste Isolation Pilot Plant: States and Tribal Concerns, Proposed Solutions - 81.106	40	5	4
Nuclear Regulatory Commission	**19**	**16**	**16**
U.S. Nuclear Regulatory Commission Scholarship and Fellowship Program - 77.008	12	15	15
U.S. Nuclear Regulatory Commission Minority Serving Institutions Program (MISP) - 77.007	2	1	1
U.S. Nuclear Regulatory Commission Nuclear Education Grant Program - 77.006	6	-	(0)
Total	**69**	**38**	**40**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 21. Estimates of nuclear transformation-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Energy	**174**	**133**	**137**
Nuclear Energy Research, Development and Demonstration - 81.121	174	133	137
National Science Foundation	**1**	**64**	**25**
Mathematical and Physical Sciences - 47.049	1	64	25
Engineering Grants - 47.041	0	0	1

Table 21. Estimates of nuclear transformation-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016 (cont.)

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
Nuclear Regulatory Commission	**2**	**0**	**2**
U.S. Nuclear Regulatory Commission Office of Research Financial Assistance Program - 77.009	2	0	2
Total	**177**	**197**	**164**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.

Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Energy efficiency, conservation and end use. Taken together, support for end use-related activities decreased from $4.9 billion in FY 2013 to $4.0 billion in FY 2016 (see Table 22 for direct expenditures and Table 23 for R&D). The Low Income Home Energy Assistance Program administered by the HHS, funded at $3.4 billion, accounted for almost 85% of the FY 2016 total. R&D program expenditures in these areas totaled $389 million, with most of this support originating at DOE.

- **The Low Income Home Energy Assistance Program (LIHEAP).** HHS administers the LIHEAP program, largely through state energy offices. This program provides direct payments and technical assistance to individual consumers, households, and multi-family building owners and tenants. Although a portion of LIHEAP support is used directly for energy consumption and could be considered a subsidy for consumption, the program is designed to free-up low-income consumer funds for other critical needs (rather than simply increasing energy services) and to provide information and assistance for energy conservation, weatherization, and other efficiency-enhancing measures. LIHEAP funding levels were $3.2 billion in FY 2013 and $3.4 billion in FY 2016.

Table 22. Estimates of conservation, efficiency, and end-use energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**36**	**25**	**6**
Denali Commission Program - 90.100	-	4	3
Rural Energy for America Program - 10.868	36	19	2
Assistance to High Energy Cost Rural Communities - 10.859	0	1	0
Sun Grant Program - 10.320	0	0	-
U.S. Department of Energy	**3,193**	**925**	**254**
Weatherization Assistance for Low-Income Persons - 81.042	1,818	313	182
State Energy Program - 81.041	522	141	44
Energy Efficiency and Renewable Energy Information Dissemination, Outreach, Training and Technical Analysis/Assistance - 81.117	19	22	21
State Energy Program Special Projects - 81.119	9	11	7
National Industrial Competitiveness through Energy, Environment, and Economics - 81.105	0	-	-
Energy Efficiency and Renewable Energy Technology Deployment, Demonstration and Commercialization - 81.129	1	0	-
Office of Scientific and Technical Information - 81.064	-	-	-
Energy Efficient Appliance Rebate Program (EEARP) - 81.127	214	(0)	-
Inventions and Innovations - 81.036	0	1	-
Geologic Sequestration Site Characterization - 81.132	-	-	-
Energy Efficiency and Conservation Block Grant Program (EECBG) - 81.128	549	436	-
Industrial Carbon Capture and Storage (CCS) Application - 81.134	61	-	-
U.S. Department of Health and Human Services	**5,614**	**3,247**	**3,368**
Low Income Home Energy Assistance - 93.568	5,614	3,247	3,368
U.S. Department of Housing and Urban Development	**259**	**-**	**(2)**
Assisted Housing Stability and Energy and Green Retrofit Investments Program - 14.318	259	-	-
Multifamily Energy Innovation Fund - 14.319	-	-	(2)
U.S. Department of Labor	**62**	**(0)**	**(0)**
Green Jobs Innovation Fund Grants - 17.275	62	(0)	(0)
U.S. Department of the Interior	**6**	**2**	**0**
Minerals and Mining on Indian Lands - 15.038	6	2	0
Tribal Energy Development Capacity Grants - 15.148	-	-	-
U.S. Department of Transportation	**220**	**23**	**-**
Clean Fuels - 20.519	4	8	-
Capital Assistance Program for Reducing Energy Consumption and Greenhouse Gas Emissions - 20.523	216	15	-
U.S. Environmental Protection Agency	**101**	**-**	**-**
National Clean Diesel Emissions Reduction Program - 66.039	101	-	-
Total	**9,491**	**4,222**	**3,625**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 23. Estimates of conservation, efficiency, and end-use energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**-**	**-**	**3**
Agricultural Research Basic and Applied Research - 10.001	-	-	3
U.S. Department of Defense	**-**	**-**	**49**
Basic Scientific Research - 12.431	-	-	43
Basic, Applied, and Advanced Research in Science and Engineering - 12.630	-	-	6
U.S. Department of Energy	**643**	**569**	**280**
Conservation Research and Development - 81.086	587	454	147
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	18	87	116
Renewable Energy Research and Development - 81.087	34	28	18
Geologic Sequestration Training and Research Grant Program - 81.133	3	-	-
U.S. Department of Transportation	**-**	**-**	**-**
Hydrogen Storage Research and Development - 20.764	-	-	-
U.S. Environmental Protection Agency	**3**	**2**	**2**
Surveys, Studies, Research, Investigations, Demonstrations, and Special Purpose Activities Relating to the Clean Air Act - 66.034	3	2	2
National Science Foundation	**156**	**135**	**54**
Mathematical and Physical Sciences - 47.049	103	84	35
Engineering Grants - 47.041	53	51	18
Total	**801**	**706**	**389**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Electricity transmission and grid network. Support for transmission grid-related programs was dominated by the DOE's Electricity Delivery and Energy Reliability Research, Development and Analysis program. This program accounted for 92% of total expenditures in this category. The program was expanded under ARRA and fell from $824 million in FY 2013 to $15 million in FY 2016 as ARRA funding authorities expired.

Table 24. Estimates of electricity transmission-related energy-specific direct expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Agriculture	**4**	**9**	**4**
Assistance to High Energy Cost Rural Communities - 10.859	4	9	4
U.S. Department of Energy	**-**	**-**	**8**
Energy Efficiency and Renewable Energy Information Dissemination, Outreach, Training and Technical Analysis/Assistance - 81.117	-	-	8
U.S. Department of the Interior	**-**	**-**	**0**
Minerals and Mining on Indian Lands - 15.038	-	-	0
Tribal Energy Development Capacity Grants - 15.148	-	-	-
Total	**4**	**9**	**11**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Table 25. Estimates of electricity transmission-related energy-specific research and development expenditures by department and program, FY 2010, FY 2013, and FY 2016

million 2016 dollars

Department and Program - CFDA Number	FY 2010	FY 2013	FY 2016
U.S. Department of Defense	**-**	**-**	**0**
Basic, Applied, and Advanced Research in Science and Engineering - 12.630	-	-	0
U.S. Department of Energy	**553**	**862**	**24**
Electricity Delivery and Energy Reliability, Research, Development and Analysis - 81.122	518	824	15
Advanced Research and Projects Agency - Energy Financial Assistance Program - 81.135	1	10	8
Renewable Energy Research and Development - 81.087	34	28	-
National Science Foundation	**13**	**25**	**25**
Engineering Grants - 47.041	4	4	15
Mathematical and Physical Sciences - 47.049	8	21	9
Total	**566**	**887**	**49**

Notes: Totals may not equal sum due to independent rounding. Zero denotes rounding to zero value and a "-"symbol denotes a zero value. Appropriations made in either FY 2010, FY 2013, or FY 2016 federal agency budgets may be obligated and fund programs in subsequent fiscal years. DOE and totals exclude DOE's Office of Science, Office of Science Financial Assistance Program.
Sources: U.S. Department of Energy, Office of the Chief Financial Officer, *Base Financial Data*, FY 2010, FY 2013, and FY 2016; Department of the Treasury, Bureau of the Fiscal Service, *USASpending.gov - Government spending at your fingertips;* website: https://www.usaspending.gov/, accessed December 1, 2014 (FY 2010 and FY 2013) and accessed November 16, 2017 (FY 2016); and, U.S. General Services Administration, *2014 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2014) https://www.cfda.gov/downloads/CFDA_2014.pdf, accessed December 1, 2014 and *2017 Catalog of Federal Domestic Assistance*, (Washington, DC, October 2017) https://www.cfda.gov/downloads/CFDA_2017.pdf, accessed December 1, 2017.

Textbox: Research and development for general application

Research and development (R&D) in this report is treated as applying to specific parts of the U.S. energy system based on the research topics, program descriptions, and other available information, including information from the programs themselves in some cases.

R&D is broadly characterized as either basic or applied, or sometimes as upstream or downstream R&D investment, with upstream referring to basic research. R&D investment is more generally applicable to a wider variety of activities, both energy-related and non-energy-related, when the activity is aimed at basic or upstream technological improvement.

Basic R&D activities are not intended to support specific kinds of energy; instead they support advances in broadly applicable technologies such as high-speed computing or basic science such as physics. This concept is true of certain Department of Energy programs, notably those of the DOE's Office of Science (SC) under CFDA 81.049, the Office of Science Financial Assistance Program. EIA did not include these activities as line items in the direct expenditure and R&D expenditure tables for this report. With total FY 2016 outlays reported at $1.2 billion, the specific DOE financial programs and FY 2016 outlays in this category include the following:

- Office of Advanced Scientific Computing Research at $39 million
- Office of Basic Energy Sciences at $303 million
- Office of Biological & Environmental Research at $130 million
- Office of Fusion Energy Sciences at $168 million
- Office of High-Energy Physics at $117 million
- Office of Nuclear Physics at $181 million
- various small business research and technology transfer DOE programs at $214 million

Mr. BABIN. Thank you. There is no such table in 2016's report explaining how much that we are paying per megawatt hour for energy, so I understand that since we rely on them to call and report impartial data, the Energy Information Administration, it has a certain amount of autonomy from your direct management. But I would ask you, Mr. Secretary, would you be willing to offer your support for them to resume producing this same chart in future research products? Americans deserve to see the destinations of where their tax dollars are going.

Secretary PERRY. Yes, sir, absolutely.

Mr. BABIN. Would you be willing to do that?

Secretary PERRY. And I think it's it makes abundant good sense for the EIA to put that forward and make it public and so the American people can take a look at how their tax dollars are being——

Mr. BABIN. Absolutely. Thank you, and I really appreciate that because here we are in the age of energy independence here in the United States with all the developments in fossil fuel production, and do the American taxpayers need to continue that type of mammoth subsidies for this type of energy?

Secretary PERRY. Yes, sir.

Mr. BABIN. Thank you, Mr. Chairman. I yield back.

Chairman SMITH. Thank you, Mr. Babin.

And the gentlewoman from California, Ms. Lofgren, is recognized.

Ms. LOFGREN. Well, thank you, Mr. Chairman, and thank you, Mr. Secretary, for being here to talk with us about your department. And I was glad to hear from Mr. Foster and others how much time you've spent looking at our national labs and—which is a great asset to our country, just miles and miles of brilliant people all over the country coming up with things that are going to change our future.

One of the things I'd like to focus on today has to do with something that's going on at the Lawrence Livermore National Lab, and that is the National Ignition Facility. I have—you know, Livermore Lab is not in my district, but it's something I've been interested in for a long time and I've followed since its inception. I was glad to hear you say this morning that fusion has the potential to change the world. We know fusion exists because we have a sun, but we're not sure when we will achieve it. We're achieving fusion now, we're just not achieving ignition. And when we do, that's a gamechanger for the world.

So given the potential benefits and the money that we spent to make this facility a reality, it was disappointing to see the budget recommendation. Now, I know that the Secretaries don't always get the last say on what is requested. The OMB has a big role, and we all served with Mick Mulvaney when we he was here in the House, and I got along well enough with Mick when he was here, maybe better than in his current position.

I was concerned that the budget would effectively result in a 40 percent reduction of shots at the NIF from 400 to 250, it would eliminate 160 jobs out of the 750 associated with that. It even eliminated funding for General Atomics, again not in my district down in San Diego that provides the target fabrication, which

would actually increase the cost. If you don't have a target, you don't have a program. If you have targets but you eliminate funding for the only source of those targets, you're going to increase the cost.

So I'm wondering—I know that the Appropriations Committee is working on this. It's possible that some changes will be made here, but I'm just wondering if you can talk about what you think about fusion and NIF's future.

And I want to say something else. You know, the new graduates in high-density physics don't necessarily want to work only on the weapons program. They want to work on science programs. And if we eliminate our pipeline of physicists into these labs by cutting the science, we're not going to be able to do the Stockpile Stewardship Program, which is the main function of course of the National Ignition Facility. So I wonder if you could comment——

Secretary PERRY. Ms. Lofgren, I——

Ms. LOFGREN. —on any of those things?

Secretary PERRY. Yes, ma'am, thank you. And I agree with your observation about the intellectual pipeline. And one of the reasons that we are valiantly trying to express our support for Westinghouse so that the United States can maintain its position on the reactor side, it's just like kids—when I was going to college, all the really smart kids wanted to be nuclear engineers. And for about 40 years because of benign neglect and some other events, some accidents, et cetera, nuclear power, civil power became kind of out-of-favor.

This fusion side I think gives us the opportunity, and I think we can reasonably have our disagreements about, you know, we are not going to have the funding for every worthy initiative, we know that, and—but we can have these conversations back and forth, which are important. And whatever this committee and Congress decides on from the standpoint of your priorities, we're going to manage them as well as can be done.

Ms. LOFGREN. Thank you. And I know my time is up. I'd just like to say we spent a lot of money building this facility, and to walk away from it after we've built it, you know, now that China is on our heels, you know, we want to be the leader. We want don't want to be behind China on this. So thank you, Mr. Secretary.

Chairman SMITH. Thank you, Ms. Lofgren.

The gentleman from Florida, Mr. Dunn, is recognized for his questions.

Mr. DUNN. Thank you very much, Mr. Chairman. And thank you, Mr. Secretary, and your Under Secretaries, for joining us here today. I found a lot to celebrate in looking at your budget, but I'd like to focus on a small niche in it that's the medical use, the healthcare use of medical isotopes.

Secretary PERRY. Oh, yes.

Mr. DUNN. So when Under Secretary Dabbar was with us here back in January, we discussed the market availability of a variety of medical isotopes and how the isotope program in the Department of Energy is actually run more like a business than it is an agency. And I was just wondering where in this budget are we looking to invest in American capabilities to generate the full array of medical

isotopes so that we're not dependent on foreign sources for high-priority medical isotopes.

Secretary PERRY. Yes. This kind of fits into the same arena as some of our rare earth minerals as well, just that the United States is going to be, I think, required to supply these ourselves. And for us to do the science, to do the funding of this so that we are not beholden to countries around the world that may not have our best interest in mind. I think about cobalt and the importance that cobalt can play, lithium, the importance that Lithium-6 is going to play going forward in the pit production for the weapons side of things.

So focusing and being dependent upon U.S.-based sources of these very important elements is a focus of the Department, and you know that we will continue to prioritize the funding for these types of programs. And as I have shared with Ms. Lofgren, you know, there are a lot of worthy initiatives out there that we don't have all the funding for them all. But in this area I think that is a priority of the Administration; it is a priority of our agency.

Mr. DUNN. I'm glad to hear that. We see a lot of dependence on the newer isotopes in PET scanning, for instance, but not just PET scanning, also in therapeutics, and so I just want to make sure that the DOE is facilitating the development and actual construction of sufficiently energetic accelerators and some reactors. We need reactors, too.

Secretary PERRY. Mr. Dunn, if I can just take a little bit of a turn away from that and talk about on the supercomputing side of things. We're standing up an office that's going to be referred to as Artificial Intelligence Big Data Initiative, ABI, and the focus there is going to be on precision medicine. We were out at Lawrence Livermore talking to some of their folks who are working with University of California San Francisco neuroscientists about managing all of this big data. It's why our supercomputing investment is so important, and on precision medicine is one of those.

I mean, the great progress that I think, Dr. Babin, in the future is going to be in the ability to manage all of this big data and those supercomputers. And five of the ten fastest supercomputers in the world belong to the Department of Energy. And soon, because of Argonne and the work that we're going to do with Fermi and Oak Ridge, we're going to be back in the position of being the number one. And how long we last as number one is going to be up to us——

Mr. DUNN. It's up to us.

Secretary PERRY. —but anyway, this precision medicine, there's not much I'm more excited about than what we see with our ability to manage all this big data focused on precision medicine.

Mr. DUNN. Well, thank you very much. I look forward to spending this weekend at Argonne Lab——

Secretary PERRY. Yes, sir.

Mr. DUNN. —studying that with Under Secretary Dabbar.

And I yield back, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Dunn.

And I believe now we're going to go to the gentleman from New York, Mr. Tonko.

Mr. TONKO. Thank you, Mr. Chair.

And, Secretary Perry, it's good to see you again——

Secretary PERRY. Yes, sir.

Mr. TONKO. —and it's good to see the work you continue to do in terms of visiting the national labs and supporting the DOE workforce.

I want to ask you about two important programs, however, within the office of EERE. The Weatherization Assistance Program is the largest residential energy conservation program in our nation. It reduces the energy burden on low-income families and creates jobs. State energy program enable States to assist with energy efficiency and renewable energy projects, as well as develop critical energy emergency preparedness and response plans.

As a former Governor, you likely have witnessed the value of these programs, and you understand that on-time delivery of weatherization and state energy program funds to States is crucial to ensuring these programs continue to run and run effectively. For weatherization, most States expect this funding on July 1. Will you ensure that weatherization state grantees and state energy program grantees will receive these funds on time this year?

Secretary PERRY. Yes, sir.

Mr. TONKO. I think that's critical.

Turning to a different DOE office, do you believe that the Office of Electricity research programs are valuable in terms of their potential to improve grid reliability and resilience through technologies such as storage, microgrids, and other smart grid technologies?

Secretary PERRY. I do, Mr. Tonko. I believe it's important that we again recognize the—and I can't remember who—I think was Mrs. Johnson I was having the conversation earlier about the prioritization. And as some of these programs mature, then the funding will obviously fall off for them as we look to the next big thing that's out there. And I think this fits right in to this area that you're making comment about as well.

Mr. TONKO. Well, earlier this year, DOE announced the creation of the Office of Cybersecurity, Energy Security, and Emergency Response, and I'm not necessarily opposed to this reorganization but I would like to understand how it might affect existing programs that will remain within the Office of Electricity. Cybersecurity is an important issue. That deserves to be elevated, but it should not be done at the expense of other critical programs.

Secretary PERRY. Yes.

Mr. TONKO. So are you committed to ensuring that there are sufficient resources and personnel for the Office of Electricity Grid Modernization and Energy Storage Programs, which are also essential for improving grid reliability?

Secretary PERRY. Yes. And we are continuing to fund—"beyond batteries" is in that shop, hydrogen R&D is in that shop. When I was out—I believe we were at Savannah River. We were looking at hydrogen fuel. And I don't want to get deep in the weeds here, but this is pretty exciting stuff when you look at hypersonic aircraft and the ability to be anywhere in the world in I mean literally 4 hours, and you can do that because of this hydrogen fuel.

So there's still a lot of exciting work to be done in the EERE. Again, you know, we can have our disagreements about line item

to line item, but the commitment is still there to come up with the new big things and to prioritize them and what have you. CESER got moved over and split out from that because of the very special focus that needs to be on cybersecurity in this country today.

Mr. TONKO. Well, thank you, Mr. Secretary. The President's budget request proposes a 74 percent cut to smart grid research, a 67 percent cut to clean energy transmission and reliability, and an 81 percent cut to energy storage R&D. So if this Administration is truly committed to improving grid reliability and resiliency, then these proposed cuts need to be rethought and removed. So I appreciate whatever assistance you can provide——

Secretary PERRY. Yes, sir.

Mr. TONKO. —in making certain that these stabilizers are there that are essential.

And with that, Mr. Chair, I yield back.

Chairman SMITH. Okay. Thank you, Mr. Tonko.

And the gentleman from Louisiana, Mr. Higgins, is recognized.

Mr. HIGGINS. Thank you, Mr. Chairman.

Secretary Perry, I very much appreciate your service to your country and your continued commitment to restore energy dominance of America in your current position.

I represent south Louisiana, the epicenter of LNG expansion for the entire world. And the district I represent is commonly referred to by my Lone Star colleagues as east Texas. So keeping that in mind, I'd see a great partnership between the State of Texas and the State of Louisiana as we seek energy dominance for our nation.

I very much appreciated your comments regarding management efficiency and operating within the parameters allowed to your Department by the appropriators of this Congress. I also support the President's overall effort to reduce the size and scope of the agencies of the federal government that devour the people's treasure, so I very much appreciate your approach, Mr. Secretary, regarding the efficient operation of the Department of Energy and the agencies therein.

I'd like to ask you about grid security. The Grid Modernization Laboratory Consortium, the GMLC, is committed to advancing development of new tools and technology to increase grid resilience and particularly from cyber attacks. How does protection against EMP fit within that endeavor? And just how much focus are you placing upon? I personally think it's a great threat to our nation, and within the confines of this environment obviously being a more open discussion, could you share with us what DOE is doing regarding the EMP protection of our grid?

Secretary PERRY. Yes, sir. I'll just speak in a generalization that that is certainly one of the challenges that we have and we recognize it. The work that they're doing at Idaho National Lab with the test grid there, it's—they're addressing it is I think the appropriate thing for me to share with you at this time.

The consortium supports, you know, the critical research and development in a host of different areas, advanced storage. Beyond batteries that I mentioned earlier is certainly one of those clean-energy integration standards and test procedures, and a number of other really key modernization areas, the least of which is not making sure that the grid is protected from cyber attacks, from

EMP-type of attacks, and other anomalies that could be released upon our grid so that the American people will know with some surety that when they flip the switch on, the lights will come on.

Mr. HIGGINS. Thank you for that answer. And just please share with this Committee regarding the budget and what you envision as required to secure our nation's grid against EMP. Are you satisfied with the budget that you received? Can you work within those parameters?

Secretary PERRY. Yes, sir.

Mr. HIGGINS. Do we need to help you by increasing that budget?

Secretary PERRY. We can work within the parameters.

Mr. HIGGINS. Thank you, sir, for your answer.

Mr. Chairman, I yield back.

Chairman SMITH. Thank you, Mr. Higgins.

Mr. Secretary, we know you have to leave for a Cabinet meeting. Thank you for spending the time you have with us. And I understand Mr. Dabbar can continue to stay and answer Members' questions. Mr. Dabbar is the Under Secretary for Science, so I think he'll be able to address most of the Members' comments and questions after the Secretary leaves.

Let me also say that I'm going to need to excuse myself, Mr. Dabbar. I have a Judiciary markup that's ongoing, so I'm going to head there.

But we appreciate again, Mr. Secretary, your being here, Mr. Dabbar, your being willing to stay. I know we have at least three Members more on either side, and up next is the gentleman from Florida, Mr. Crist. So Mr. Secretary, as soon as you leave, we'll recognize Mr. Crist to address his questions to Mr. Dabbar.

Mr. CRIST. Governor——

Secretary PERRY. Governor, I wish I could stay and hang out with you.

Mr. CRIST. I wish you could, too.

Secretary PERRY. It's good to see you, sir.

Mr. CRIST. It's good to see you, sir.

Secretary PERRY. My day job requires me to walk across the way and—but if there's—in all seriousness to each of the Members that are still here, if there are questions that you need me or want me to address personally, I will make that happen in some form or fashion. But I'm leaving a very capable fellow right here, although he could not get into Texas A&M. He had to go to the Naval Academy. They trained him up pretty well. So, anyway, thank you, Mr. Chairman.

Mr. CRIST. Thank you, Mr. Secretary. Thank you, Mr. Chairman, and thank you, Under Secretary Dabbar, for being able to stay here and help us out today.

My hometown, which is the city of St. Petersburg, Florida, was one of the first cities in the country to commit to transitioning to 100 percent renewable energy. It's a lofty goal, and I commend the city for being proactive in reducing carbon emissions. However, I am concerned that the cuts to the energy research and development within this budget proposal will make that goal much more difficult. Those cuts happen to include a 66 percent cut to renewable energy, an 80 percent cut to energy storage research and development within the Office of Electricity, and complete elimination

of the Loan Programs Office, just to name a few. Do you think that this budget proposal will spur the kind of American innovation that's needed to help my hometown of St. Petersburg and other communities meet their clean energy goals?

Mr. DABBAR. Thank you, Congressman, Governor. I very much appreciate that question.

Mr. CRIST. Certainly.

Mr. DABBAR. As the Secretary said, line items on budgets are subject to your appropriation and your focus. Our focus is to take the resources that you give us and to maximize that. And we are very excited. I think as you may know, the cost-effectiveness of solar and wind and other renewables in the last decade has dramatically improved in part—large part because of the Department and the national lab complex.

Another area is also in batteries and storage. And so what we're trying to do is to try to take the—not only the great research that you fund but also try to push it out into the market and also very importantly push it out into the market so that it's manufactured here in the United States. And so those are the areas that we're focused on. And we continue to take the resources that you give us and build on the accomplishments and all those in many other areas for St. Petersburg and other localities that want to attack it that way.

Mr. CRIST. Great. Thank you. Earlier this year, the President imposed a four-year tariff on solar cells. I understand that you may not have had any direct involvement with that decision, but I have some very serious concerns about the impact it's having on our domestic solar industry. The Solar Energy Industries Association says that this tariff could cost as many as 23,000 American jobs this year alone. Meanwhile, as far as I'm aware, no one has really given an estimate as to how many manufacturing jobs would be created. That plus the 72 percent cut to solar in this budget makes me think that the solar industry may be under fire. What is the Department of Energy planning to do to support those companies, their employees, and the solar industry as a whole when they have been negatively impacted by this tariff?

Mr. DABBAR. Thank you. So the primary focus for the Department is around innovation and technology. That is our primary focus. Sir, as you said, we are not involved in some of those points that you were just mentioning. So what we're really focused on—and I'll talk about solar—is what is the next technology? And it's great that there's been significant improvement in cost and therefore affordability and applicability within—for localities to deploy solar and wind and others. But a big focus for us is what's next. What can we continue to move down the cost structure and develop those technologies?

So on solar, for example, perovskite crystals is a new area that we think could continue to drive down potentially the cost curve and make it even more affordable for St. Petersburg and other places to attack. And once again, we're very focused on that and we're very focused on once again those new technologies hopefully being developed and built here.

Mr. CRIST. Great. Thank you, sir. I appreciate that. I want to switch gears and talk briefly about offshore drilling. I know that

the Interior Department handles that issue primarily, but as Governor of Florida when Deepwater Horizon exploded and I was a Congressman representing a coastal district, offshore drilling is always at the forefront of my mind. In Florida our economy is really dependent upon our environment vis-a-vis tourism. The threat that offshore drilling poses to our oceans and coastal communities is not worth the risk in my opinion. I know that may be different where the Secretary is from in Texas where drilling does significantly contribute to the economy. I simply ask that you appreciate that States like mine are concerned with the Administration's proposal and that you share our concern with the Secretary, as well as other members of the Cabinet, as appropriate. And I appreciate you being here again, and I yield back.

Mr. LUCAS. [Presiding] The gentleman yields back.

The Chair recognizes the gentleman from Alabama, Mr. Brooks, for four minutes.

Mr. BROOKS. Thank you, Mr. Chairman.

Hopefully, you're the right individual to ask, but if not, if you would please relay this question to Secretary Perry.

The Trump Administration says it wants to revive the nuclear industry because developing new nuclear projects is critical to the long-term viability of the nuclear industry. Currently, the Vogtle plant is under construction, and there is also an additional proposal to finish two new nuclear plants at Bellefonte in my Congressional District. Hopefully, you are aware of them.

Many billions of dollars were spent by TVA on the two Bellefonte plants, and completion was substantially underway before the spending of those monies was stopped. If those plants are completed, that will bring thousands of jobs and billions of dollars in private sector money to the economies of Alabama, Georgia, and Tennessee, as well as creating a reliable source of nuclear power with essentially no greenhouse gases.

It is important to have viable financing support through programs like the Department of Energy loan guarantees, and I understand that an important goal of the *Energy Policy Act of 2005* is to encourage the construction of more nuclear plants, including those involving public-private partnerships via programs like those Department of Energy loan guarantees.

That being the question—the case and before you respond to my two questions, let me add that Under Secretary Moniz, who appeared before our Committee, and his staff have been in communication with us and we appreciate the reference.

So here are the questions. First, can you comment on the status and future of the Department of Energy loan guarantee program as it pertains to the Bellefonte project specifically or else generally? And second, will the Administration commit to expanding America's nuclear power fleet?

Mr. DABBAR. Thank you, Congressman. So on your first question, yes. In addition to talking with your office, the Loan Program Office has been engaged in talking with the team that has the option to purchase the Bellefonte plant, and they're very much continuing those conversations. And, you know, within the context is what's the authority? What is required in order to meet the requirements

of the loan is ongoing with them. So I can confirm that that is taking place, as well as the conversations with your office directly.

Around the area of commercial nuclear in general, I think as the Secretary said, several times making references to Westinghouse and development, as well as both his and my comments around it, the request on the advanced nuclear program, as well as on safe fuel that we just issued a new FOA on this last week is a high degree of focus for us. It's important for us as a country to continue our leadership on a broad range of issues for commercial nuclear, and we appreciate the consideration for that request in the budget.

Mr. BROOKS. Thank you, sir.

Mr. Chairman, I yield back.

Mr. LUCAS. The gentleman yields back.

The Chair now recognizes the gentleman from Virginia, Mr. Beyer, for four minutes.

Mr. BEYER. Thank you, Mr. Chairman. I'd like to begin by submitting to—for the record if there's no objection a letter from 87 bipartisan Members of the House to Chairman Simpson and Ranking Member Kaptur on Appropriations on ARPA–E Energy Innovation Hubs and EFRCs.

Mr. LUCAS. Seeing no objection.

[The information follows:]

Congress of the United States
Washington, DC 20515

March 16, 2018

The Honorable Mike Simpson
Chairman
Energy and Water Development, and
Related Agencies
House Appropriations Committee
2362-B Rayburn House Office Building
Washington, DC 20515

The Honorable Marcy Kaptur
Ranking Member
Energy and Water Development, and
Related Agencies
House Appropriations Committee
1016 Longworth House Office Building
Washington, DC 20515

Dear Chairman Simpson and Ranking Member Kaptur:

As Members with a strong interest in ensuring our nation's future energy security, we thank the subcommittee for continuing to fund several key Department of Energy (DOE) research and innovation programs and request that these programs are given high priority as you consider the Fiscal Year (FY) 2019 Energy and Water Appropriations bill. We are specifically writing to support three complementary approaches to tackling the critical energy innovation challenges before us: the Advanced Research Projects Agency-Energy (ARPA-E) program, Energy Innovation Hubs, and Energy Frontier Research Centers (EFRCs).

As you know, DOE plays an important role in the development and incubation of clean energy innovation that benefits our nation and the economy. DOE programs such as these support scientific research and technological advances at multiple stages of the innovation pipeline. These programs represent a robust portfolio of energy R&D investments, each of which complements the others to maximize our nation's ability to achieve energy breakthroughs as quickly as possible. These programs, outlined below, deserve your highest consideration.

- **ARPA-E: $346.5 million**
- **Energy Innovation Hubs: $108.4 million**
- **EFRCs: $110 million**

Advanced Research Projects Agency-Energy (ARPA-E): With significant federal investments, the DOD-funded Defense Advanced Research Projects Agency (DARPA) has been responsible for some of the most innovative technological breakthroughs of our time, from Global Positioning Systems (GPS) to the Internet. ARPA-E was created to replicate the successful DARPA model by incentivizing researchers to develop promising research into game-changing technologies that can meet our future energy needs. Despite the potential for a huge payoff, the private sector does not invest sufficiently in this kind of "high-risk, high-reward" energy research. Supporting ARPA-E is a bet on Americans' proven ability to turn creative ideas into market-creating, job-growing businesses. Since 2009, 136 of these projects have attracted more than $2.6 billion in private sector follow-on funding. For FY 2019, we request $346.5 million to enable ARPA-E to continue to invest in innovative ideas.

Energy Innovation Hubs (Hubs): The Hubs are large, integrated research centers involving multiple disciplines, investigators, and institutions with a focus on bridging the gap between scientific breakthroughs and industrial commercialization. The Hubs use a centralized, mission-oriented research approach like that employed by the Manhattan Project or at AT&T's Bell Laboratories. To date, DOE has established and Congress has supported five hubs focusing on: Fuels from Sunlight; Modeling and Simulation for Nuclear Reactors; Batteries and Energy Storage; Critical Materials; and Desalination. For FY 2019, we request $108.4 million to fully fund the five hubs.

Energy Frontier Research Centers (EFRCs): EFRCs consist of small groups of researchers focused on the fundamental science that underlies roadblocks to revolutionary energy technologies, such as interfacial chemistry for solar energy conversion and electrical energy storage. Unlike the Hubs and ARPA-E, these centers specifically focus on long-term chemical and materials science for energy applications. The centers also play a significant role in training graduate students in scientific disciplines central to overcoming energy-related grand challenges. After 2016, there are now 36 EFRCs with related research activities being conducted in 35 states and Washington, DC. For FY 2019, we request $110 million to support these centers.

America's innovation history is built on a foundation of robust federal investment in fundamental scientific research. At the same time, the public sector has a deep history of working hand-in-hand with the private sector to bring the fruits of this research to market, address market failures, provide needed expertise, and raise capital for high-payoff, though riskier, projects in which industry would not otherwise invest. Without such partnerships, the stories of the transcontinental railroad, the aviation sector, and biotechnology industries would be dramatically different. As in these past projects, the government has a critical role to play in helping to support and foster the new ideas that will serve as the foundation for the nation's future energy economy.

Thank you for your consideration of these important DOE innovation programs.

Sincerely,

Donald S. Beyer Jr.

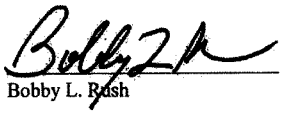
Carlos Curbelo

Anna G. Eshoo

Brian Fitzpatrick

Elizabeth H. Esty

Patrick Meehan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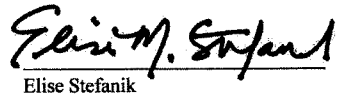
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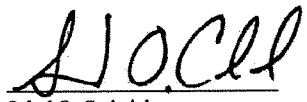
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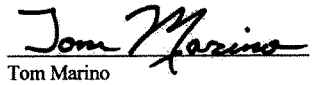
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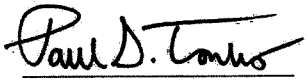
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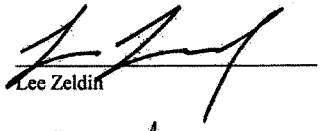
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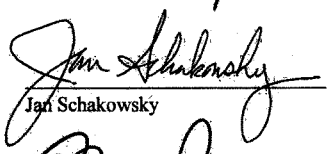
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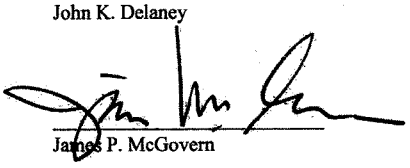
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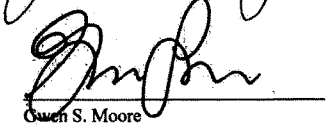
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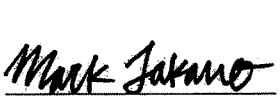
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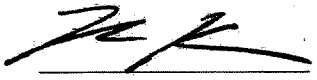
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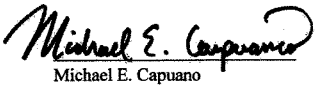
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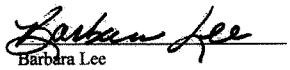
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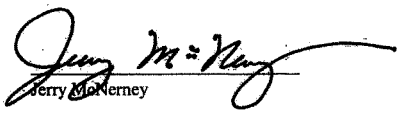
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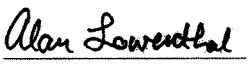
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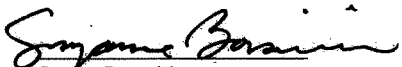
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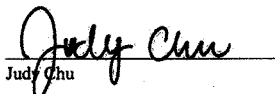
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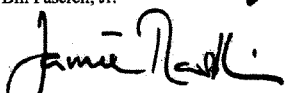
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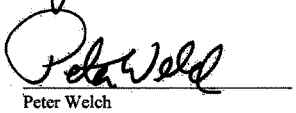
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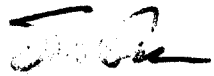
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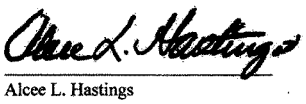
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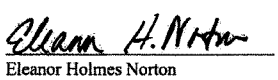
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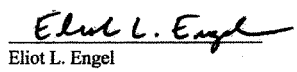
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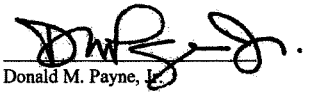
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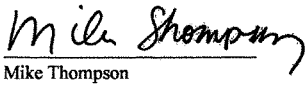
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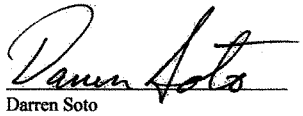
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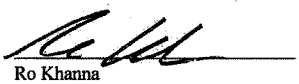
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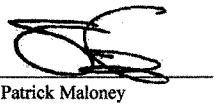
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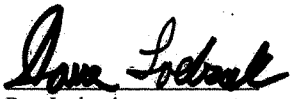
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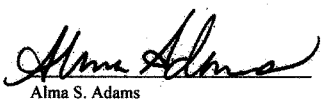
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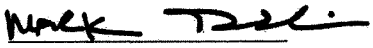
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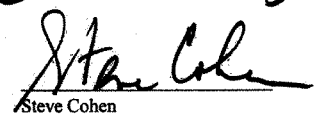
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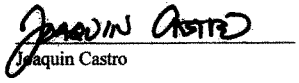
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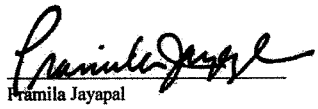
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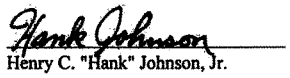
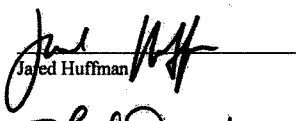

Henry C. "Hank" Johnson, Jr.


John Garamendi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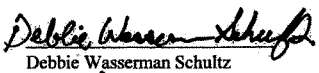
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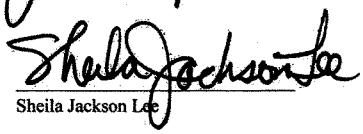
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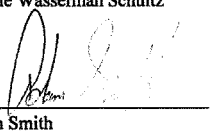
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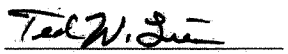
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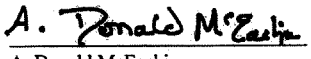
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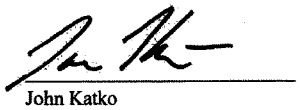
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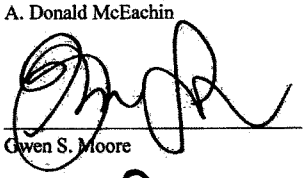
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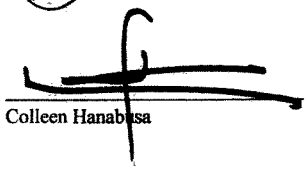
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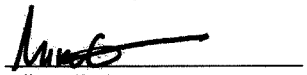
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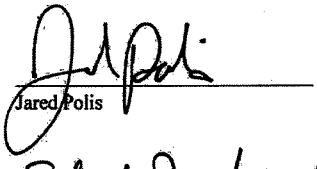
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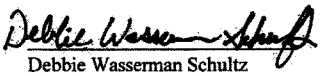
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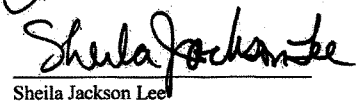
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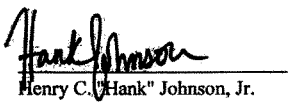
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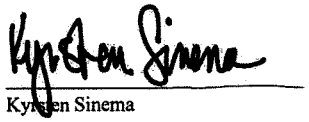
Peter King


William R. Keating


Kyrsten Sinema

Karen Bass

Mr. BEYER. Thank you very much.

Under Secretary Dabbar, you know, we live with yesterday's tragic news of President Trump's decision to withdraw from JCPOA, the Iran deal. Secretary Perry's predecessor, Dr. Moniz, a nuclear physicist, was deeply and extremely involved in the building and the—of the negotiations that surrounded the deal. Do you have any evidence that Iran was failing to meet its obligations under the JCPOA or any reason that would justify the United States' reneging on its commitment to JCPOA?

Mr. DABBAR. I apologize, Congressman. I don't have any, nor have I participated in, any conversations with the Department around that topic.

Mr. BEYER. I wonder. It's—you know, I'm far down the pecking order, but it would be wonderful in the appropriate way to request you would pass these questions on to Secretary Perry.

Mr. DABBAR. I——

Mr. BEYER. And try to get these back within 24 hours if possible?

Mr. DABBAR. Well, I'll pass it along to the Secretary about your question, and he'll follow up——

Mr. BEYER. And whatever——

Mr. DABBAR. —with what's appropriate——

Mr. BEYER. —from a staff perspective, whatever formal way we can get these entered would be also—I also think it's a little tragic that the Under Secretary for Science would not be included in those discussions. I certainly know that the science folks at the previous Department of Energy were deeply involved.

You know, the Secretary has consistently referred to the resiliency and reliability of the grid as the reason for the concern about the nuclear and coal power plant closures. When the Secretary used his power under section 403 to appeal to FERC to bail out the coal companies in the name of resilience, FERC rejected that request. And now FirstEnergy has asked the Secretary to invoke his 202(c) power under the Federal Power Act and prevent PJM, the electrical distributor, from retiring plants.

Assistant Secretary Bruce Walker said the DOE would never use an emergency order under section 202(c), the Federal Power Act, to prop up an uneconomic generator. And PJM has demonstrated that their retirement of plants do not affect the reliance of the grid. Republican FERC Commissioner Neil Chatterjee just yesterday said that the retirements will not impinge on resilience. And if FirstEnergy's bailout is granted, it would raise the cost of electricity by $8 billion annually for its consumers. It would discourage any investments in clean energy resources and begin the slippery slope of the federal government dictating the energy mix of States. So do you have any idea whether the Secretary intends to reject this bailout of FirstEnergy?

Mr. DABBAR. So I can't comment on ongoing discussions specifically on that, but obviously, it's an important aspect of what we do from a technology point of view regarding reliability and power. A lot of what we do at the Department is evaluate and look at technologies associated with the changing energy mix. Obviously, taking baseload power off has an impact. That's an obvious point. And a lot of energy has been replaced with intermittent. And, you know,

we think it's appropriate for it to be reviewed and it is being reviewed.

Mr. BEYER. Great. Thank you. And perhaps we can also send this question to the Secretary, too, on his intentions on the bailout.

Mr. DABBAR. We'll pass the question along, too, also Congressman. Thank you.

Mr. BEYER. Thank you very much.

And lastly, we know that a diverse grid incorporates renewables but that their intermittent reliability and intermittency is an issue and that battery storage, especially grid-scale battery storage, is the key to this diverse and resilient grid that you talk about. Do you know—are you supportive—is the Secretary supportive of FERC order 4—841 that directs the ISOs and the RGOs to develop market rules to more fully integrate energy storage as a resource on the electric grid?

Mr. DABBAR. Congressman, I can't comment specifically to the FERC order, but I can say that, in general, including battery storage as reliability backup to the electric grid, is an important technology that we're providing and I think should get properly included in the market structure.

Mr. BEYER. And I'm really impressed that AEP, which is—or AES rather, which is headquartered in my district in Rosslyn just across the river that their single biggest project right now is battery storage facility in California.

Mr. DABBAR. So——

Mr. BEYER. Globally, so——

Mr. DABBAR. So battery storage is a major focus of what we're looking at around commercialization, a much longer topic, but one of the things that we focused on around commercialization of what are the major technologies that you all and the taxpayers have allocated money, and the one area that we're attacking first is how do we accelerate the technologies that we've developed on new chemistries for batteries that could potentially be much better than the lithium-ion.

The first event that we're doing, a first multi-lab event that we're doing on how to push forward stronger our technologies is on batteries. We're doing that at Stanford in conjunction with the university and our SLAC laboratory where we're inviting all the labs together to meet with industry to figure out how do we take the next wave of technologies on batteries beyond lithium-ion as we like to call it and how to move that forward for the country.

Mr. LUCAS. The gentleman's time has expired.

The Chair now recognizes the gentleman from South Carolina, Mr. Norman, for five minutes.

Mr. NORMAN. Thank you, Mr. Dabbar.

Can you give us an update on the DOE's approval of the Advanced Manufacturing Collaborative that's located in Aiken, South Carolina? And as you know, the intent is to have a workforce training of manufacturing jobs.

Mr. DABBAR. So I can repeat again that this is a high degree of focus for us. This is something that we are completely supportive of at the Department, and we continue to work with OMB around getting the final approvals of this, and we certainly hope that we will be able to do that in the near future.

Mr. NORMAN. Do we have a timing that you would think?

Mr. DABBAR. I would hope it's quite near, but it's been quite near for a little while, and I can say it has a disproportionately high focus within the Department compared to the cost.

Mr. NORMAN. We appreciate that. Later this month, the Committee will hold a hearing on technology that supports veterans. Here, we will include a witness from your department who will be providing us information on the MVP Champion program. It's very important to veterans. Can you give us some update on that?

Mr. DABBAR. Yes, Congressman. So just—as people may know here, the Department of Energy has a long history in the bio area in genomics, and with a very long history, and so this is quite consistent with what the Department has done over time. One of the things that we have a great leadership role in the world is supercomputing and applying that to various different health topics, including around genomics. This is a program that we are continuing to move along, work with the VA and work with the National Institutes of Health. And we continue to move that along, and it's a part of funding discussions as part of this budget.

Mr. NORMAN. And if you could provide this committee with information, updates I guess on it on how it would be impacting exactly what we would be doing, and we would appreciate it. And if there's anything that you think we can do as a Congress, we'd definitely like to know that.

Mr. DABBAR. Thank you, Congressman. We'll follow up with that detail, and it is an important area, and we'll get you that detail if that would be helpful for your deliberations.

Mr. NORMAN. Thanks so much. I yield back.

Mr. LUCAS. The gentleman yields back.

The Chair now recognizes the gentleman from the big 1st District of Kansas, Dr. Marshall, for five minutes.

Mr. MARSHALL. Yes, thank you, Chairman.

Let me start by saying thank you. Excuse me. The Secretary lined out several of your vision, your goals, stewardship, accountability, and service, and several of my folks back home in the energy sector have said indeed, under this Administration, things are going in a positive direction. Especially my friends from the Cuyahoga, Kansas, oil and gas industry expressed their gratitude.

I've been waiting here so long my throat got scratchy.

The Secretary has been a leader to ensure resiliency of the electric grid and has proposed that several proposed actions that could favor fuels with onsite storage like nuclear and coal. How could this approach disadvantage natural gas in particular, which is currently the most affordable fuel on the market, and what steps is the Department taking to invest in grid resiliency without picking winners and losers in the energy market?

Mr. DABBAR. Yes. So thank you, Congressman. You know, I think it's been a long history of this country to have diversity. The all-of-the-above is an important aspect to it. Obviously, natural gas has had significant improvements in technology, and whether it's in turbine efficiency or production costs. And once again, we do feel this is generally appropriate, as has been a bipartisan view of having diversity across all the energy types and that we can continue

that. So we consider natural gas just as important as nuclear and coal.

What other areas are we focused on around grid resiliency? This is a particularly interesting area for me as Under Secretary of Science. What one particular area that we're focused on is in machine learning and artificial intelligence. Collecting data from the grid on all the different data points around weather, around wind, around solar intensity, around demand that's coming up the next day or the next week as a result of those coming through, all the capabilities of the power plants, the costs associated with interconnections is a great example of the applicability of machine learning for potential grid management. And we actually have a number of different machine-learning algorithms on how to optimize the grid that will help resiliency, will help dispatch to lower costs, and it's a particularly very interesting area for us that, in addition to the points that the Secretary made earlier that I wanted to point out on this important topic.

Mr. MARSHALL. Okay. Next, I want to talk a little bit about low-dose radiation health risk. As a physician, it's been an area of concern. We certainly know that at some point there's an all-or-nothing phenomena for radiation, whether dealing with a pregnant woman or an adult, and we don't really know, you know, where those limits are for low-dose radiation. And the House proud that we passed H.R. 4675, the *Low-Dose Radiation Research Act*.

Under the previous Administration, research in this area was abruptly called to a stop for some reason. Can you commit today to restore the Department's leadership in this field of science?

Mr. DABBAR. Congressman, as a user of low-dose radiation earlier in my nuclear engineering days, I'm completely sympathetic of the topic. We certainly have been discussing this. Certainly, we've been getting up to speed on the past work that has been done. And should you appropriate that exactly how we would take it forward, so should that happen, should you appropriate, we actually have specific ideas and plans. We're really focused on the genomics aspects, which is a bit new compared to the previous work in the last Administrations that have focused on this topic. There's obviously an area of focus for and expertise for the Department should it be appropriated.

Mr. MARSHALL. Right. I spent a little time exposed to some low-dose radiation myself in a nuclear reactor at Kansas State University.

Lastly, I'd like to just talk about CFIUS for a second, in particular referring to Citgo. I don't know all the details but I think Russia recently invested in Citgo, some concern on my part about a Russian zoning refining industries in this country and just wonder if the Department has any concerns about this.

Mr. DABBAR. I apologize. I'm not the right person, but we can certainly follow up with that question.

Mr. MARSHALL. Okay. Thank you, and I yield back.

Mr. LUCAS. The gentleman yields back.

The Chair wishes to thank both the Secretary and the Deputy Secretary for their testimony and the Members for their questions.

The record will remain open two weeks for additional written comments and questions from the Members.

This hearing is adjourned.
[Whereupon, at 10:51 a.m., the Committee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by the Hon. Rick Perry

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

QUESTIONS FROM CHAIRMAN SMITH

Q1. In your prepared testimony, you highlighted the Department's support for early-stage quantum technology research and stress that the United States will not "satisfy our need for computing advances with the achievement of exascale computing alone." There is broad support from U.S. academic institutions, scientific research organizations and the private sector to enact a National Quantum Initiative to accelerate the development of commercially available quantum-based technologies to keep pace with accelerating international competition. Would you support federal investment in a National Quantum Initiative and what role should DOE play in that initiative?

A1. The Department of Energy's (DOE) Office of Science (SC) has developed a coordinated quantum information science (QIS) strategy that builds on DOE's and SC's unique strengths such as the capabilities, expertise, and community resources that are resident in the DOE national laboratory complex, and adopts an approach that focuses on cross-cutting themes among the SC core programs. The Department's QIS strategy is well-aligned with the proposed National Quantum Initiative. DOE brings a strong foundation of intellectual capital and demonstrated leadership in launching interdisciplinary science teams for large-scale and long-term investments to the National Quantum Initiative, and these strengths will foster advancements in fundamental science and the development and deployment of community tools, equipment, and instrumentation to accelerate the development of quantum-based technologies.

Q1a. With quantum research outpacing the individual laboratories, it seems like there needs to be shared large-scale facilities and supporting infrastructure that would provide stable scientific and engineering platforms for quantum technology and software development. Do you think DOE should take a center-based approach – similar to the Nanoscale Science Research Centers – to fast-track quantum research?

A1a. DOE's Nanoscale Science Research Centers are an excellent example of the type of scientific user facilities that are critical for accelerating progress in quantum information science. The Nanoscale Science Research Centers will play a key role in the fabrication, characterization, and testing of quantum structures and devices up to mesoscale through innovative instrumentation and multi-lab synergies and by providing new quantum technologies in partnership with the Advanced Scientific Computing Research's quantum

test beds. A centers-based approach will need to be balanced with a portfolio of core research.

Q2. In quantum technology, there is a major gap between university research and industrial development. This gap threatens U.S. advancement in a field that holds the keys to next generation navigation, computing, communication and security. In order to stay ahead of our international competitors, how do you plan to develop a workforce prepared to advance quantum technology in the United States?

A2. DOE plans to develop a quantum technology workforce through support of graduate students and postdoctoral researchers through our research grants and support for undergraduate internships and graduate student thesis research at national laboratories. In addition, the Department's Computational Science Graduate Fellowship program will expand its efforts to identify and support future quantum technology leaders.

Q3. In your testimony to Congress on the FY 2019 budget, you have been asked a lot of questions about the future of ARPA-E. What is your opinion on the concept of expanding ARPA-E's role in the Department to include research and technology development across the broader DOE mission – such as nuclear waste clean-up, cybersecurity technology, and even identifying technology solutions to national threats. Do you believe that with an expanded mission goals, ARPA-E could help the Department quickly develop technology solutions in these areas?

A3. Under the proposed reorganization and modernization plan for DOE, aspects of APRA-E would be consolidated with DOE's other applied energy research programs into a single Office of Energy Innovation. The goal would be to take "a holistic view of energy innovation to ensure Federal research keeps pace with the changing needs of the Nation's energy system while maximizing the value to the taxpayer" including aspects of ARPA-E; furthermore, "ARPA-E features positive aspects, such as coordination with industry and cross-cutting research" but it does not need to be independent of DOE's main applied research programs. (See "Delivering Government Solutions in the 21st Century—Reform Plan and Reorganization Recommendations" issued by the Office and Management Budget, attached as Appendix A.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

The proposed reorganization and modernization plan for the Department has been a preliminary effort with high-level conversation between DOE and OMB. The Department is still evaluating elements of the proposal to form its judgments on how best to implement the proposal. Any proposed changes would comply with existing statutory and regulatory requirements.

Q4. From deep space robotic missions to mobile and emergency power, the U.S. is in need of cost-effective, small-scale, and transport-ready energy sources. What steps, if any, are you taking to support basic and early-stage research in solar and fusion energy for space, military and civilian applications?

A4. Solar photovoltaics (PV) are inherently well-suited to small-scale and lightweight needs, as it has the same performance at any size. The Department's Solar Energy and Technologies Office (SETO) PV research focuses on 1) reducing costs by examining new materials, processing techniques, and cheaper inputs; 2) understanding and mitigating degradation to increase PV lifetime; and 3) increasing efficiency by identifying defects, opportunities to incorporate tandem/multi-junction cell architectures, and solar cell material interface passivation. SETO has a broad portfolio of relevant PV research at universities, national laboratories, and private companies.

Examples of relevant SETO-funded research include: Using advanced hydride vapor-phase epitaxy hydride to grow lower-cost III-V solar cells, which are highly efficient and lightweight; Driving down the costs of multi-junction III-V solar cells, which have record power conversion efficiencies over 45%; and Developing large-area perovskite cells that have reasonable lifetimes, are potentially cheap, flexible, and lightweight, and could be fabricated quickly and domestically.

The Fusion Energy Sciences (FES) program in the Office of Science supports research to build the scientific foundation needed to develop a fusion energy source for civilian applications. Currently it is envisioned that such fusion energy sources would be neither sufficiently small-scale nor transport-ready for mobile energy needs. However, the early-

stage research supported by FES should be applicable to any fusion energy source, independent of configuration and size.

Many of the Department's technology advances could potentially support space, military, and civilian applications in the future.

Q5. What is the status of the Department's efforts to accelerate the deployment of advanced reactors?

A5. The Department is using financial assistance and grant opportunities to advance the Office of Nuclear Energy (NE) mission to accelerate the development and deployment of new reactor designs. In fiscal year (FY) 2018, the Department issued a unique, 5-year United States (U.S.) Industry Funding Opportunity Announcement (FOA) to support the most innovative ideas driving the development and commercialization of domestic nuclear technologies. This funding is expected to result in technologies that enable new commercially available products. In FY 2019, additional funds are expected to be made available through current NE programs and the new Advanced Small Modular Reactor (SMR) Research and Development (R&D) program to support R&D, including design-related R&D, for the safest, most innovative SMRs and micro-reactors.

Q5a. What about efforts, like the Gateway for Accelerated Innovation in Nuclear or GAIN Initiative, designed to support the commercialization of advanced reactor technologies by providing the nuclear community with direct access to the technical, experimental facilities, and ability to demonstrate technologies at national labs? Is there any plan to expand this successful program?

A5a. The GAIN Initiative is supporting the U.S. nuclear power industry through private-public partnership, and addressing issues that may prevent successful commercialization and global competiveness. Examples include, but are not limited to, easy access by developers to unique facilities within the DOE complex and financial support for expensive R&D.

Within available FY 2018 funding, NE initiated a new "Industry Opportunities for Advanced Nuclear Technology Development" FOA. This FOA is open for up to a five-year period and applications will be accepted on a year-round basis with selections announced every quarter. Selections to-date include 15 FOA awards and an additional 7 GAIN voucher awards for a total of 22 U.S. industry-led, cost-shared projects for approximately $80M in federal funding for cost-shared research and development for advanced nuclear technologies. GAIN vouchers fund work to be performed at DOE national laboratories on behalf of U.S. businesses.

In FY 2018, the Department also supported testing at DOE's experimental facilities through its Nuclear Science User Facilities (NSUF) program. NSUF provides U.S. researchers with access to unique and highly-specialized nuclear research capabilities, instrumentation, and scientific support. These include the Advanced Test Reactor, the Transient Test Reactor, and many partner facilities with advanced capabilities that are necessary to accelerate advanced reactor technology deployment.

The Department's plans to support acceleration of the deployment of advanced reactors for FY 2019 include the continuation of GAIN engagement, additional awards to U.S. industry through the FOA, and the expansion of NSUF's access to unique nuclear science capabilities and expertise, with a focus on U.S. industry support.

Q6. What is the Department doing to ensure its grants for advanced nuclear reactor companies do not interfere with private industry activities by distracting or diluting resources that would otherwise benefit industry in a cross-cutting fashion?

A6. The Department is providing financial assistance grants and cooperative agreements to a number of companies that are expected to support a pipeline of domestic advanced reactors designs. The work supported under these private-public partnerships is expected to provide valuable data, capabilities, and designs that can be accessed by the U.S. nuclear industry to improve their designs and manufacturing capabilities. There is no

expectation that financial assistance provided for advanced reactors will distract or dilute resources provided for cross-cutting research activities through other NE programs.

Q6a. What about licensing support programs? Couldn't DOE providing licensing support grants actually make it more difficult for privately financed advanced reactor companies to get through the NRC process, since the NRC has limited resources available for nuclear reactor licensing?

A6a. The FY 2018 Omnibus Appropriations Act Committee Report refers to DOE issuing "a solicitation to support technical, first-of-its-kind engineering and design and regulatory development of next generation light water and non-light water reactor technologies...." DOE believes that providing licensing support grants in connection with this solicitation is highly unlikely to interfere with private licensing activity. The grants funded will be a source of new ideas, creating an opportunity for U.S. companies pursuing deployment of advanced nuclear technologies to interact with the Nuclear Regulatory Commission (NRC) and to explore new concepts and new applications for nuclear energy. Furthermore, in responding to the licensing activities supported by DOE grants, awardees will provide information to NRC that may be useful in NRC's efforts.

Q7. The Fossil Energy Research and Development program leads the federal research, development, and demonstration efforts on advanced carbon capture, and storage technologies. Earlier this year, the Department announced a request for information for the design, construction, and operation of a small-scale, modular coal-based pilot-scale plant. Can you discuss how this new proposal will help open new opportunities for coal-fired power plants?

Q7a. Modular plants are thought to be an option to lower cost, improve efficiency, and improve flexibility to meet load demands. What are some examples of DOE's research that could help industry accomplish these goals for new modular systems?

A7a. R&D on modular system design will focus on the development of new materials and computational modeling that can be adapted by industry to design smaller, more reliable and efficient reactors to increase deployment opportunities. Advancements in modular systems could overcome siting, operating, and logistical constraints that currently inhibit

the deployment of large scale plants. In addition, R&D in this area will also enable improvements in existing plant efficiencies through topping cycles, advanced materials, recovery of low grade waste heat, improvements in water usage, lower parasitic losses and the development of advanced sensors, instrumentation, and artificial intelligence control systems based on dynamic data analysis.

DOE envisions that the coal-fired fleet of the future may be based on power systems with the following characteristics:

- Reduced design, construction, and commissioning schedules from conventional norms
- Modular, maximizing the benefits of high-quality, low-cost shop fabrication to minimize field construction costs and project cycle time
- Designs developed with advanced process engineering and parametric design methods
- Simplified maintenance features
- Integration with energy storage, coal upgrading, or other plant value streams
- Near-zero emissions, including carbon capture ready
- Capable of high ramp rates
- Load following capability down to 25% of Maximum continuous rating (MCR)
- Minimized water consumption

This envisioned plant would be of modular design and capable of distributed generation; have a greater than 40% efficiency improvement, thereby reducing operating costs and overall emissions; use state-of-the-art materials and processes, including advanced sensors and controls to maximize its efficiency and further minimize emissions; and be economically competitive.

The plant would also be equipped with advanced emission control systems. This includes the plant either being "carbon capture ready" or deploying carbon capture for enhanced oil recovery, utilization, or storage. This plant would be a critical contributor to the grid

of the future, and offer both "firm and flexible" operations—providing stable power with operational flexibility and high efficiency, such that it can quickly meet the needs of the evolving grid.

The following research areas could contribute to accomplishing these goals: advanced materials (e.g., for condensers, turbines, boilers and heat exchangers); sensors and controls for efficient, flexible operation; condition-based maintenance; parametric system designs; advanced manufacturing (especially for modular, shop-built fabrication); gasification; fuel cells; gas turbines; supercritical carbon dioxide power cycles; simulation-based engineering; and energy storage.

Q7b. Do you think the development of small modular fossil fuel plants could face similar hurdles to the development of small modular nuclear reactors?

A7b. Small modular fossil fuel plants should have the same beneficial attributes as small modular reactors (SMRs) including lower overall cost, the ability to site the plants in more locations, the ability to incrementally add units as needed, and the ability to factory manufacture and mass produce components and parts with an accompanying reduction in construction costs. Due to the nature of fossil power plant operations, developing a new, scaled-down version of a coal or natural gas burning plant could be done with significantly less construction and operational uncertainty than SMRs. Specifically, small modular fossil fuel plants would not face the degree of regulatory oversight currently impacting the design, certification, and eventual operations of an advanced nuclear plant such as an SMR.

Q8. The United States no longer has an active uranium enrichment industry, and the only work being done on an existing domestic enrichment technology is at a small demonstration program in Oak Ridge. There is particularly the lack of low enriched uranium above 5%, which is needed for many advanced reactor designs. Based on the progress being made by advanced reactor developers towards deployment, it is likely that some of these designs may be licensed and built, but unable to load fuel. What is the Department doing to ensure this does not happen?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A8. Currently, there is no capability in the United States to produce High-Assay Low-Enriched Uranium (HALEU), which is uranium enriched to between 5% and 20% U-235. A continuing lack of a HALEU production capability could adversely impact the deployment timetable for advanced reactor systems. Establishing HALEU production capability is critical to U.S. leadership in this emerging market sector, and to advancing vital strategic interests, and some quantities of HALEU fuel will be needed to support research, technology development or licensing support activities well before a reactor concept can be licensed or constructed.

Q8a. And what is the Department doing to restore and advance domestic uranium enrichment capabilities?

A8a. The Department's Office of Nuclear Energy is exploring several options to ensure that necessary quantities of HALEU are available to advanced reactor developers for demonstrating and deploying advanced reactors. These options include down-blending highly enriched uranium and enriching uranium to higher levels than currently being produced. Down-blending options consist of potential reuse of material from the treatment of Experimental Breeder Reactor II fuel, as well as the recovery of enriched uranium from used naval reactor fuel. We are also working closely with industry stakeholders to improve forecasts of the quantity of material, specifications and timing to meet the needs of developers. These planning efforts are coordinated with the National Nuclear Security Administration's efforts to identify a source of enriched uranium for a variety of mission needs. A domestic source of U.S.-based enrichment technology would improve our ability to meet strategic energy security objectives.

Q9. H.R. 4367, the "Department of Energy Research Infrastructure Act of 2017," authorizes upgrades and construction of major user facilities at the Department of Energy (DOE) national labs within funding allocated to the Basic Energy Sciences Program and the Nuclear Physics Program within DOE's Office of Science. If this legislation is enacted, what steps will you take to ensure that these key facilities receive the resources necessary to finish construction on time and on budget?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A9. The Office of Science (SC) supports a balanced portfolio of (1) forefront basic research, (2) the upgrade and construction of world-leading scientific user facilities, and (3) the operation of these facilities. Each facet of this portfolio is essential to maintaining international competitiveness and providing the foundation for many applications of potential societal benefit. Within available funding, SC balances these aspects of the portfolio and continues to successfully deliver our highest priority investments in facility upgrades on time and on budget.

In addition, SC has a well-documented approach to project management oversight that adheres to DOE Order 413.3B. As part of this process, major construction projects are baselined for cost and schedule, including contingency, by the SC Office of Project Assessment. Once a project baseline has been established, the SC annual budget requests include the resources needed to successfully implement the project.

Q9a. Do you believe that research infrastructure is the primary way DOE supports innovation at the national labs?

A9a. Research infrastructure is an essential, enabling resource supporting innovation at DOE labs. However, the primary engine driving U.S. innovation is the principal investigators at universities and national laboratories. DOE support for research infrastructure creates unique opportunities at DOE labs at the frontiers of science and technology. DOE support for principal investigators at universities and national laboratories leverages those opportunities to create innovative technology and new knowledge, underpinning U.S. competitiveness and national security. Both of these elements are essential.

Q10. DOE has a long history of public-private partnerships in the Fossil Energy Research and Development (FER&D) program, and the National Energy Technology Laboratory (NETL) spearheads this research. However, NETL remains the sole government operated laboratory the Department oversees. Could you describe the differences in research performed in the GOCO vs. GOGO model? Why is this GOGO model the best option for the fossil energy lab?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A10. One of the main benefits of the GOGO model is ownership of the full RD3 lifecycle. Rather than early stage research being performed by one entity (National Lab) and then technology maturation being managed at the Program Office level in conjunction with Industry, the GOGO model enables integration and synchronization of the early-stage and technology maturation research portfolios. This integration better focuses early-stage research, enhances collaborations with researchers in academia, industry, and other National Laboratories, and increases the ability to consistently provide better science and research results.

Other GOGO benefits include the ability to be integrated with HQ in strategy development and convening authority among stakeholders to further collaboration. A GOGO National Lab is uniquely positioned to act on behalf of the Government and provide unbiased, science-based analyses of energy policy, legislation, and regulations.

Q11. The FY 2019 budget request proposes a shift away from large, commercial scale carbon capture and storage projects, to small pilots to demonstrate first generation technologies in carbon capture, storage, and carbon use and reuse. This should restore the relationship between DOE and industry, allowing DOE to develop next generation technologies, but giving industry the responsibility to take those technologies to commercial scale. Can you provide us with an update on some of the technology innovations DOE is pursuing in the fossil energy program?

A11. DOE's Carbon Capture Program is pursuing technology innovations to reduce the cost and energy required to separate carbon dioxide from flue gas (post-combustion carbon capture) or synthesis gas (pre-combustion carbon capture). The R&D effort is focused on advanced solvents, solid sorbents, and membrane systems. In addition, process engineering improvements and hybrid approaches are being investigated to reduce cost and improve efficiencies.

DOE's Carbon Storage Program is also pursuing technology innovations to advance the effectiveness of onshore and offshore carbon storage, reduce the challenges to its implementation, and prepare the way for widespread commercial deployment. The R&D effort is developing, field-testing, and integrating technologies and data throughout the

entire value chain (e.g., site characterization, monitoring). These technologies are focused on reducing risks and costs while ensuring safe, permanent storage. The program is also advancing our fundamental understanding of fluid migration in the subsurface and developing technologies for real-time monitoring and geo-steering—all of which also benefit the associated storage of carbon dioxide in enhanced oil (or gas) recovery operations.

DOE's Carbon Use and Reuse Program is pursuing technology innovations to utilize carbon dioxide to cost-effectively create valued products while making no additional contribution to carbon emissions. The R&D effort is developing catalysts and efficient manufacturing techniques to convert carbon dioxide into plastics and chemicals, possibly using waste energy or other alternative energy resources to drive the conversion process. In addition, technologies are being developed to convert carbon dioxide to solid minerals and to utilize carbon dioxide in the manufacture of high-strength cement.

Q11a. What tools does the Department need to better leverage federal resources to advance fossil energy innovation?

A11a. The Fossil Energy Research and Development (FER&D) program advances transformative science and innovative technologies that enable the reliable, efficient, affordable, and environmentally sound use of fossil fuels. Fossil energy sources constitute over 80% of the country's total energy use, and are important to the nation's security, economic prosperity, and growth. While the percentage of coal used for electricity generation has dropped over the past decade due to increased capacity from renewables and generation by natural gas plants, according to EIA data, coal is projected to play a critical role to our economy by providing electric power for decades to come. In addition to power generation, coal is a crucial feedstock for the steel and cement industries, two industries that are essential to our infrastructure.

The Transformative Power Generation program, for example, would support improving the efficiency and reliability of existing and new power plants by developing and

applying advanced new materials, instrumentation and monitoring equipment, and controls systems that improve the efficiency and reliability of existing units over the load range.

By enabling the continued operation of the coal fleet, this program can support domestic coal jobs by helping to revitalize the industry. It can also help to improve reliability of the nation's power grid by sustaining and potentially expanding reliable baseload power across the nation.

DOE remains committed to creating commercially viable economic solutions to protect our environment and enhance our nation's energy independence. A reliable and resilient electrical grid is critical not only to our national and economic security, but also to the everyday lives of American families. Coal can play a significant role in ensuring grid resiliency and reliability.

Q12. Within DOE programs, can you provide an example of an advancement in technology that could only have been accomplished with DOE support?

A12. An emblematic example is chrome molybdenum steel, also known as chrome-moly steel, which is significantly stronger and more heat- and corrosion-resistant than normal steel and is used today in an extraordinarily wide range of applications from nuclear reactor vessels, steam tanks, and coal-fired plants, to aircraft parts, vehicle axles, and high-end bicycle frames. It was developed at Oak Ridge National Laboratory in the 1970s for use in a planned Tennessee Valley Authority nuclear reactor and went on to find countless applications in all corners of the modern economy. The development of chrome-moly steel exemplifies the central role that DOE and the DOE national laboratories have played in the discovery and development of new materials to drive American technological progress and innovation. This role has two major dimensions. First, the Department provides the largest share of direct Federal support for materials science and engineering research, with much (though not all) focused on materials in extreme conditions—such as those required for nuclear reactors or other energy production

facilities. SC has been the major supporter of basic research in this area but has also long cooperated with the Office of Energy Efficiency and Renewable Energy (EERE) and the Office of Fossil Energy (FE) in helping to accelerate the transition from discovery to market. Second, SC's major scientific user facilities—in particular, the five large x-ray light sources and the two neutron scattering sources at the national laboratories—have driven discovery by providing ever deeper insight into the microstructure of materials, enabling the development of a wide range of lighter, stronger materials for aircraft, vehicles, and other applications. In addition, we are moving increasingly toward an era of rational design of materials, drawing on the Department's world-leading high-performance computing capabilities to accelerate the discovery process through computation. In short, the Department's role in advancing materials research and discovery, as a core energizer of technological innovation and the American economy, has been and continues to be nothing less than indispensable.

Another example of revolutionary changes underway in the U.S. energy economy has been the advent of solid-state or LED (light-emitting diode) lighting—a technology that largely owes its existence to substantial DOE investments in both basic and applied research over recent decades. LED bulbs, which rely on semiconductors rather than filaments to generate light, are at least 75 percent more efficient than incandescent bulbs and last 25 times longer. Their use is bringing significant energy savings for both individual households and the Nation as a whole—with the promise of more down the road. Roughly a third of U.S. households are currently using at least some LED bulbs, according to a recent report by the Energy Information Agency, and LED bulb use is steadily spreading. It is estimated that by 2027, LED lighting across the Nation could save the equivalent of the output of 44 1000-megawatt energy plants, or $30 billion in today's energy costs. Through both SC and EERE, DOE supported both the basic and the applied research needed to develop this technology and transition it to the marketplace. The Department has sponsored over 290 research projects in solid-state lighting that generated more than 290 patents and patent applications. SC supported key

advances in the chemistry and precise technique of deposition needed to produce the LEDs as well as computer modeling that led to better understand the principles governing the operation of these semiconductors. EERE has partnered with industry to translate these discoveries into practical products and continues to work with industry to improve performance. Today you can walk into any supermarket, hardware, or big box store and purchase energy-saving LED bulbs for your home at a very reasonable price—a possibility that would not have existed in the absence of major DOE investments in both basic and applied science.

Another example is the development of a world-first hybrid laser-mechanical drill assembly technology through the support of Foro Energy by ARPA-E. The project proposed combining a rotating drill bit with a new laser transmission system to project laser radiation onto the rock surface while rotating. The novel approach, combining laser and mechanical drilling technologies, could support accessing next-generation energy resources in a more timely and cost-effective manner. During its ARPA-E award, Foro demonstrated a world-first ability at surface to drill hard rock at 10 feet per hour over multiple hours of operation on test bedrock, as well as project 20kW laser energy for 12,000 feet distance in a rig-hardened fiber optic cable. The ARPA-E project opened the door to applications in drilling geothermal wells, and a novel technique for safe oil and gas well completion.

Q12a. What about investments that are better suited for private industry to undertake? Are there any examples in DOE's current portfolio where you feel the private sector might be better suited to take the lead?

A12a. The DOE Office of Science supports basic and use-inspired basic research that may be characterized as discovery research; industry research is primarily focused on applied uses that serve the interests of the company.

Q13. The Department's FY 2019 budget request, proposes to eliminate the Advanced Technology Vehicles Manufacturing Loan Program and the Title 17 Innovative Technology Loan Guarantee Program. The President's recently issued rescissions

request from prior year appropriations also includes cuts to prior year balances for these programs.

DOE has an excellent track record of funding basic and early-stage research, and allowing the private sector to finance and deploy new technologies. DOE's track record on the loan program is less than successful, with over $800 million in taxpayer dollars wasted on bad loans to failed technology companies. Do you believe the Department should get out of the finance business, and focus on the research and development it does best?

Q13a. Why is it beneficial to the private sector to have the federal government only fund basic and early-stage research, and not compete with private financing for technology deployment?

A13. The Budget proposes to eliminate the Title XVII Innovative Technology Loan Guarantee Program, the Advanced Technology Vehicle Manufacturing (ATVM) Loan Program, and the Tribal Energy Loan Guarantee Program, because the private sector is better positioned to finance the deployment of commercially viable energy and advanced vehicle manufacturing projects.

The Federal role in supporting advanced technologies is strongest in the early stages of research and development. The Government should not be in the business of picking which technologies "win" the commercialization race and displacing private sector investment opportunities. Instead, the Government should recognize the private sector's primary role in taking risks to finance projects in the energy and automobile manufacturing sectors.

Q14. The Department has prioritized maintaining the resiliency and reliability of the electric grid, including proposing new FERC rules to prioritize reliable fuels like fossil and nuclear power. What is the Department doing – particularly in the applied energy research programs that are under this Committee's jurisdiction – to ensure that those reliable energy sources can remain a competitive part of America's power grid?

A14. In the Light Water Reactor Sustainability program, DOE's Office of Nuclear Energy (NE) is conducting R&D to improve the economics, reliability, and maintain high levels

of safety in the existing fleet through plant modernization and risk-informed systems analysis. The plant modernization R&D efforts will enable modernization of plant systems and processes while building a technology-centric business model platform that supports improved performance at a lower cost. Specifically, this area is investigating human performance improvement for nuclear power plant field workers; outage safety and efficiency; centralized online monitoring and information integration; and integrated operations, automated plants, and hybrid control rooms. The risk-informed systems analysis R&D is focused on the benefits associated with an enhanced, resilient plant; assessing alternative margin recovery strategies; and supporting risk re-categorization and risk-informed plant enhancements. NE is also conducting R&D to leverage contributions from nuclear fission beyond the electricity sector through the Hybrid Energy Systems program. Currently, this program is investigating the feasibility of integrating an existing nuclear power plant with a large-scale desalination process for the treatment of regional brackish groundwater and evaluating the potential for hydrogen production via nuclear energy to support a broader industrial ecosystem.

Q15. The Joint Center for Energy Storage Research (JCESR) is a consortium of national labs, universities, and industry partners, including, Argonne National Lab University of Illinois, Northwestern, and University of Chicago. It integrates discovery science, battery design, and pre-commercial prototyping in one interactive organization focused on developing next-generation batteries beyond current lithium-ion technology. Now that JCESR is 5 years into its work, what lessons have we learned? What impacts has this consortium had on speeding the development of battery technology?

A15. Over the past five years, the Joint Center for Energy Storage Research (JCESR) has focused on advancing the understanding of the fundamental electrochemistry for advanced electrical energy storage solutions that are critical to the Nation for a reliable electrical grid and improved batteries for vehicles, as well as addressing the materials challenges required for these solutions. JCESR has focused on the development of an atomic-level understanding of reaction pathways and development of universal design rules for electrolyte function for battery systems that go beyond lithium-ion with an emphasis on discovery of new energy storage chemistries. JCESR pioneered the use of

technoeconomic modeling to provide a "cost" consideration in setting its fundamental research directions for next generation batteries. JCESR research has significantly advanced new energy storage pathways including demonstration of a new class of membranes for anode protection and flow batteries, elucidation of the characteristics required for multivalent intercalation electrodes, understanding of the chemical and physical processes that must be controlled to protect the inventories of active materials in lithium-sulfur batteries and greatly improve cycle life, and computational screening of over 16,000 potential electrolyte compounds using the Electrolyte Genome protocols.

JCESR's early stage research, based on a strong partnership among national laboratories, universities, and industrial participants, has created a library of fundamental scientific knowledge of the phenomena and materials of energy storage at the atomic and molecular level and demonstrated a new paradigm for battery R&D—integrating discovery science, innovative architectures, computational methodologies, and research prototyping to foster advances for energy independence and economic competitiveness.

Q15a. Now that the first five years of the Hub has been completed, what should the next five years JCESR look like if it is renewed? How important is its work to developing the next-generation battery and storage technologies?

A15a. JCESR was renewed in FY 2018, and the emphasis is on the discovery of new materials and chemistries beginning at atomic and molecular levels. Among the drivers for the research is transformational performance, such as increased stability to improve battery lifetimes and enhance safety, for stationary storage critical for the electrical grid, and advances for transportation. DOE is proactively leveraging the research efforts across the Department to translate scientific advances to technology applications.

Q15b. In the Committee's House-passed H.R.589, it gives the Department some discretion on the continuation and closure of these initiatives. Which Hubs provide the most value to the innovation engine? Would you reprioritize, eliminate, or start new initiatives based off the Administration's priorities?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A15b. Both JCESR and the Joint Center for Artificial Photosynthesis are making critical contributions to the Nation's future. Rapid progress in battery technology will be vital to both transportation and the grid. Artificial photosynthesis holds out the promise of a revolutionary new clean energy source from sunlight. Both Hubs have excellent track records based on performance to date.

DOE will continue to assess whether other scientific and technical challenges can be best addressed through a Hub-like modality.

Q16. The Department's August 2017 "Staff Report on Electricity Markets and Reliability" acknowledges, cost-competitive energy storage "will be critical" to balance the grid under high levels of variable renewable energy. As electricity systems move towards greater variable renewables, large-scale energy storage will become increasingly important – capturing excess electricity, including renewable energy generation, when demand and prices are low, and then utilizing that energy during peak demand times with low storage cost. What importance is the Department placing on research in battery technologies? How does this research differ from the private sector interests and research in battery technology?

A16. The Office of Electricity's (OE) Energy Storage program is designed to develop new and advanced technologies that will ensure the stability, reliability, and resilience of electricity infrastructure. The program focuses on accelerating the development of new materials and device technologies that can lead to significant improvements in the cost and performance of grid-scale energy storage systems and accelerate the adoption of the energy storage into the grid infrastructure. In FY 2019, R&D efforts will continue to be focused on early stage high risk research of novel materials and key components for promising megawatt-scale energy storage systems, which will provide added resilience and control capabilities to the grid. Due to the high risk nature of this research, the private sector would typically underinvest in these areas.

The Office of Energy Efficiency and Renewable Energy (EERE) focuses on accelerating the application of new and advanced energy storage technologies that can be used in buildings, electric vehicles, or to help address the added variability of renewable

technologies. Sustainable Transportation programs within EERE focus on batteries and hydrogen for vehicle-based energy storage, with research aimed to reduce battery cost, volume, and weight, while improving performance (power, energy, and durability) and the ability to tolerate abuse conditions.

Q17. Late last year, the Department reorganized program responsibilities between the two undersecretary positions, and separated the Office of Science and the applied energy research offices. Over the last five months, what examples could you share with this committee on the benefits to the management change that advances the Department's goals?

Q17a. How does this management structure improve the Department's operations compared to the last administration's management structure?

A17a. Under the DOE Organization Act, the Secretary of Energy has the authority to organize the Department in order to meet the needs of the current time and support and advance the policy priorities of the Administration. This new structure supports American energy dominance, enhances our energy and national security, and improves outcomes in environmental management while ensuring DOE remains the leader in scientific innovation.

The Under Secretary of Energy focuses on energy policy, applied energy technologies, energy security and reliability, and certain DOE-wide management functions, while the Under Secretary for Science focuses on supporting innovation, basic scientific research, and environmental cleanup.

Elements of the former Under Secretary for Management and Performance's portfolio have become the responsibility of the Deputy Secretary of Energy.

This new structure enhances DOE's focus on early-stage scientific research and development and energy technology innovation, while improving environmental and legacy management outcomes.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

QUESTIONS FROM RANKING MEMBER JOHNSON

Q1. The Fiscal Year 2018 omnibus funding bill included significantly increased funding for fusion energy research, and for the ITER international fusion project specifically. The bill's report language stated that the funds are for "the in-kind contributions and related support activities of ITER." That would certainly include the required cash contributions from the U.S. to the ITER international organization to maintain the project's cost and schedule, per our long-established obligations to the project.

Q1a. Is this your understanding as well?

A1. Pursuant to direction from Congress and statutory restrictions, the Department of Energy (DOE)'s understanding is that the $122M of appropriated funds is for "the in-kind contributions and related support activities of ITER" in FY 2018, which will enable the U.S. to maintain adequate progress on the highest priority in-kind hardware contributions required for First Plasma (Central Solenoid magnet modules, structural components, and assembly tooling, as well as Tokamak Cooling Water design efforts and hardware components), but that these appropriated funds in FY 2018 do not include a cash contribution.

Q1b. Will the United States be making a cash contribution to ITER in FY 2018? What are the impacts on the cost and schedule of the U.S. contribution to ITER if we do not provide these cash contributions soon?

A1b. Pursuant to direction from Congress and statutory restrictions, the Department's understanding is that the $122M of appropriated funds for "the in-kind contributions and related support activities of ITER" in FY 2018 do not include a cash contribution. Non-provision of these cash contributions may impact the ITER Organization's ability to carry out the assembly, installation, and commissioning of the hardware systems.

Q2. Secretary Perry, at the recent ARPA-E Summit you spoke very highly of the great work taking place at ARPA-E. Your praise falls in line with many experts in academia and industry, including the National Academies and the U.S. Chamber of Commerce that believe ARPA-E's work should not only be supported, but expanded. Unfortunately, your budget proposal does the opposite.

Q2a. Why do you want to eliminate ARPA-E?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

Q2b. What expert recommendations support this proposal to eliminate ARPA-E? Can you name specific organizations or experts that agree with this move?

Q2c. What experts did you discuss this proposal with?

A2a-c. The elimination of ARPA-E has been in the President's FY18 and FY19 budget proposals, yet Congress has continued to fund the program. The House Science Committee has recently proposed reforms to ARPA-E that would give the Secretary of Energy greater discretion in prioritizing ARPA-E's research initiatives. As with all programs, DOE will follow authorizing and appropriations laws relative to ARPA-E.

Q3. As you likely know, in December the Government Accountability Office (GAO) announced that DOE had committed an illegal impoundment of $91 million in funding for ARPA-E, which violated the Congressional Budget and Impoundment Control Act of 1974. Prior to this, GAO had not found an Impoundment Control Act violation in more than a decade.

Q3a. What are you doing to ensure that this does not occur again under your watch?

A3. The FY18 budget request included a proposal to cancel $91 million in prior-year funds. As we waited for final enactment of the FY18 bill, the program did not obligate this funding, to avoid limiting Congressional prerogatives if it decided to rescind this funding. This action had no impact on funding for ongoing activities; final decisions on awards for new funding opportunities were temporarily delayed until a final bill was passed.

Q4. Your budget request declared some research as early-stage, and therefore worthy of federal support, and other activities as later-stage research that should be immediately eliminated given that the private sector is supposedly better equipped to carry them out. However during a briefing to Congressional staff, and for the second year in a row, Administration officials confirmed that they did not engage with the private sector at all while compiling the FY 2019 budget request to determine what industry would be able or willing to pick up.

Q4a. Given this complete absence of engagement with industry even as the Administration proposed massive, sweeping cuts to these programs, how did you determine what DOE should or should not support across these program offices?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

Q4b. Are the cuts proposed in the FY 2019 budget research areas that the private sector is willing to start funding after the federal government cuts them? If you didn't consult with them before proposing these massive cuts, then what are you basing these cuts on?

Q4c. Should the federal government engage with stakeholders in the private sector to understand what research areas they are likely to fund on their own before it proposes to completely eliminate or drastically reduce funding for R&D programs?

If so, do you plan to make any changes in your budget development process going forward?

A4a-c. DOE will continue to play a leading role in early-stage, fundamental energy research and innovation. This early-stage research is critical to advancing American energy innovation, and is often used by our private sector in competing across the globe. Continuing American scientific and technological leadership is important not only for improving our understanding of the world, but also for the economic growth of our nation. The FY 2019 President's Budget refocuses DOE's energy and science programs on early-stage research and development with a renewed focus on cutting-edge innovation and transitioning those breakthroughs to the private marketplace.

All funds have been released for obligation. As a result, GAO did not issue a formal report to Congress under the Impoundment Control Act. All funds have been made available, and will continue to be made available, consistent with the requirements of the Act.

Q5. The terms "early-stage research" and "late-stage research" seem to be used in a rather cavalier fashion in the FY 2019 budget as a rationale to cut a program or fund another. I have yet to see how the Department defines these terms though.

Q5a. Can you define for me what "early-stage research" is and what "late-stage research" is?

A5a. In general, early-stage research focuses on technology challenges that present a significant degree of scientific or technical uncertainty across a relatively long period, making it unlikely that industry will invest significant R&D on their own. The primary

goal of early-stage R&D is to generate knowledge upon which industry as a whole, not individual companies, can develop and deploy innovative energy technologies. The R&D results would be widely useful to or adoptable across industry.

While not interchangeable with early- and late-stage, the definitions of basic and applied research in Office of Management and Budget Circular No. A-11:
Basic research is defined as experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts. Basic research may include activities with broad or general applications in mind, but should exclude research directed towards a specific application or requirement.

Applied research is defined as original investigation undertaken in order to acquire new knowledge. Applied research is, however, directed primarily towards a specific practical aim or objective.

5b. Is it your belief that policymakers can and should draw a bright red line between "basic" and "applied" research or between early-stage and late-stage research? Or should we be realistic and identify where the government can play a valuable role in de-risking technologies and partnering with industry?

It is generally possible to distinguish meaningfully between basic and applied research. The Department's organizational structure reflects this, with the Office of Science focusing on basic research and the Department's technology offices (EERE, FE, NE, and OE) focusing on applied research and maintaining close relationships with industry. There is a very clear case for Federal support of basic research—something demonstrated by America's leadership since the end of World War II, when it was first recognized that U.S. leadership in science would henceforth be critical to America's economic competitiveness and security as a Nation. But if the Nation is to benefit fully from the discoveries of federally sponsored basic research, in many cases there needs to be a means to transition these breakthroughs to the market. The Department's applied research offices play this role in helping transition Office of Science-supported discoveries to commercialization. This has been the case, for example, with battery

technologies, where, say, a basic research breakthrough in potential cathode materials needed to be incorporated into a workable battery prototype before there could be commercial interest.

Q6. You have been exploring several policy options to provide additional support to coal and nuclear plants, and argue that they are required for the reliability and resiliency of our electric grid. You then make the point that the energy market is not free and so doesn't sufficiently value these attributes.

Q6a. However, nuclear energy has different characteristics, including zero emissions, which may provide a greater overall benefit to U.S. taxpayers than coal without carbon capture. If so, would it make more sense to provide a greater financial incentive to maintain our current nuclear fleet and support other zero emission sources of energy that better meet our nation's energy security and environmental needs, rather than lumping coal and nuclear energy together?

A6a. America's national security and energy dominance depends on a reliable, resilient electric grid powered by a diverse mix of generation resources that help mitigate disruptions and enable rapid response when disruptions occur. Coal and nuclear are fuel-secure traditional baseload resources and are essential components of our energy future. Nuclear power, for example, provides approximately 20 percent of the electricity generated in the United States, it is one of the most reliable sources of baseload power, and it is also one of our cleanest sources of power, providing about 60 percent of our carbon-free electricity.

Speaking directly to low or zero emissions technologies, several DOE early stage research and development investments support low or zero emissions technologies. The FY 2019 Budget Request provides $757 million for the Office of Nuclear Energy to continue innovating new and improved nuclear energy technologies. Furthermore, the Energy Efficiency and Renewable Energy budget funds $696 million to maintain America's leadership in transformative science and emerging energy technologies in sustainable transportation, renewable power, and energy efficiency.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

Q7. In your FY 2019 budget you request you proposed eliminating the Loan Programs Office, which has a strong performance record and has actually returned well over a billion dollars to the U.S. Treasury so far. Eliminating LPO would actually add to the national debt, not save money. Additionally, it would put the U.S. at a competitive disadvantage in developing and commercializing innovative energy technologies.

Q7a. Given the Administration's recent conditional commitment of an additional loan guarantee to the Vogtle nuclear plants that are under construction in Georgia, are you reconsidering the value of maintaining the capabilities that LPO provides in supporting our nation's energy security after all?

A7. The Budget proposes to eliminate the Title XVII Innovative Technology Loan Guarantee Program, the Advanced Technology Vehicle Manufacturing (ATVM) Loan Program, and the Tribal Energy Loan Guarantee Program, because the private sector is better positioned to finance the deployment of commercially viable energy and advanced vehicle manufacturing projects.

The Federal role in supporting advanced technologies is strongest in the early stages of research and development. The Government should not be in the business of picking which technologies "win" the commercialization race and displacing private sector investment opportunities. Instead, the Government should recognize the private sector's primary role in taking risks to finance projects in the energy and automobile manufacturing sectors.

Q8. The FY 2019 budget proposal included major cuts to FE's research activities, including an 80% cut to carbon capture, an 87% cut to carbon storage, and an 89% cut to natural gas technologies. These cuts were rationalized with a simple line about how industry can better commercialize these technologies and methods. Given how critically important these technologies are to ensuring a long-term future for coal in particular, I am trying to better understand how this proposal is consistent with the Administration's rhetoric regarding its support for developing and utilizing these resources.

Q8a. How important is carbon capture technology to the future viability of coal and other fossil fuels in a carbon constrained world? Or do you believe we should not worry about CO2 emissions from power plants?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A8a. DOE is committed to supporting research and development for transformational technologies that reduce the capital and energy penalty so that carbon capture with enhanced oil recovery is economically viable for coal-fired power plants. The reduction in the FY 2019 request reflects DOE's successes in demonstrating first-generation capture technologies, which we now deem mature enough for industry to further adapt or deploy in a commercial environment. DOE's role will be to support early-stage research in the discovery of novel materials and processes that can be accomplished in the laboratory and with advanced computing through our network of universities and national laboratories. DOE will continue to seek partnerships with industry to scale these novel technologies for commercial deployment.

Both the capture and storage program will focus on early-stage R&D, which is lower cost but higher risk. The Capture program will focus on transformational technologies for CO2 separation that will enable adoption of CO2 utilization opportunities. The Storage program will focus on early-stage R&D, focused on developing advanced monitoring and simulation tools, ensuring well bore integrity, addressing risks from induced seismicity, and characterizing offshore resources. The FY 2019 budget request also supports carbon utilization that will focus on early-stage R&D on technologies that will convert CO2/carbon waste streams from coal into valuable products.

Q9. The Office of Fossil Energy (FE) does vital research to mitigate the environmental impacts of fossil fuel utilization. But the FY 2019 budget is inconsistent with the importance of the research.

Q9a. How do you expect to carry out a successful fossil energy research portfolio by only funding "early-stage" research, especially if the private sector is not able or willing to support what you call applied or "late-stage" research that will enable fossil energy resources to be technologically viable even when future environmental regulations are eventually enacted?

A9a. We have worked diligently throughout the budget formulation process to ensure that the President's FY 2019 Budget works within budget constraints to allow us to be good stewards of taxpayer resources while also enabling DOE's critical missions of promoting

America's energy security; spurring innovation; reducing regulatory burden; restoring the nuclear security enterprise and enhancing national security through the military application of nuclear science; and addressing the obligation of legacy management and nuclear waste.

To address these challenges and improve the lives and security of all Americans, DOE's world-leading science and technology enterprise engages in cutting-edge research that expands the frontiers of scientific knowledge and generates new technologies. We, through our national laboratories, must continue to support the world's best enterprise of scientists and engineers who create innovations to drive American prosperity, security and competitiveness for the next generation.

DOE will continue to play a leading role in early-stage, fundamental energy research and innovation. This early-stage research is critical to advancing American energy innovation, and is often used by our private sector in competing across the globe. Continuing American scientific and technological leadership is important not only for improving our understanding of the world, but also for the economic growth of our nation. The President's Budget focuses DOE's energy and science programs on early-stage research and development with a renewed focus on cutting-edge innovation and transitioning those breakthroughs to the private marketplace.

9b. How can you rationalize the numerous cuts across FE's portfolio in the FY 2019 budget by saying industry is better suited to carry this work out, but also include a request for government funded research into emerging shale plays that is supported in large part by the oil and gas industry?

A9b. Fossil Energy's Unconventional Oil and Gas research program provides information, data, and analysis that can be advanced by industry to enable sustainable and responsible development of domestic unconventional energy resources. Over the past decade, Unconventional Oil and Gas production from shale plays has grown exponentially, representing a fast-growing component of the U.S. energy portfolio. However, there remain key technical and scientific questions that require research that is best addressed

through targeted federal investment. The FY 2019 budget request targets both lab-based and field work on specific topics that are early-stage and not able to yet attract industry investment. These include research on new techniques to increase recovery factors, better understand flow mechanics, basin-specific subsurface engineering, and produce water treatment technologies.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

QUESTIONS FROM RANKING MEMBER LIPINSKI

Q1. I'm concerned about the effect of the FY19 budget request on technology transfer and commercialization activities from our national labs. As you know, one of the White House's Cross-Agency Priority goals is improving the transfer of federally-funded technologies from lab to market, something the national labs do well. Yet the FY19 request proposes significant cuts to the Office Energy Efficiency and Renewable Energy, which funds technology transfer programs such as the Lab-Embedded Entrepreneurship Programs at Argonne, Berkeley, and Oak Ridge, and other Tech-to-Market programs. Can you please explain how cuts to the budgets of highly-successful technology transfer and commercialization programs are consistent with the goal of improving technology transfer?

A1. The Administration's budget reflects an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy technologies by fostering collaboration between National Laboratories, universities and companies. Through careful prioritization and ensuring that funding goes to the most promising research, DOE will continue to be a world-leading science and technology enterprise that generates the innovations that fulfill our missions ensuring the Nation's security and prosperity. In tandem, the Department is working to enhance bridge programs and partnership mechanisms that facilitate the transfer of DOE-funded technology to the private sector. Through the Office of Technology Transitions (OTT), for which the Department has requested a $1.6 million funding increase in FY 2019, the Department continues to support an array of programs that support the development of public-private partnerships.

Importantly, programs successfully launched in DOE's Office of Energy Efficiency and Renewable Energy (EERE) under the Technology-to-Market program such as the Energy I-Corps program are being transferred to OTT. Energy I-Corps trains lab researchers in the basics of customer acquisition and tailoring technology to meet market need and thereby maximize technology transfer opportunities. Successful technology transfer and commercialization efforts under the Technology-to-Market program are being continued under OTT.

Among the OTT programs is the Technology Commercialization Fund (TCF), which is authorized in section 1001 of the Energy Policy Act of 2005. It leverages the R&D funding in the applied energy programs to mature promising energy technologies with the potential for high impact. It leverages funding for the Department's applied energy research, and development budget for each fiscal year from the Office of Electricity, EERE, Office of Fossil Energy, and Office of Nuclear Energy with matching funds from private sources to achieve two goals: First, it is designed to increase the number of energy technologies developed at DOE's national labs that graduate to commercial development and achieve commercial impact. Second, the TCF enhances the Department's technology transitions system with a forward-looking and competitive approach to lab-industry partnerships.

Other successful programs supported through OTT include those transferring from their successful launch in EERE Technology-to-Market, such as Energy I-Corps, which trains Lab researchers in the basics of customer acquisition and tailoring technology to meet market need.

OTT also oversees the Energy Investor Center, which conducts outreach to the private sector to increase awareness of DOE's technical expertise and portfolio of technologies and facilitates private sector collaboration and partnerships with the National Labs.

The Advanced Manufacturing Office's (AMO's) Lab-Embedded Entrepreneurship Programs employ a high-impact, lab-based entrepreneurial R&D model to address the challenge of hardware-based technology development by leveraging the U.S. national laboratories in a new way. These programs embed top technical talent with new ideas within the national labs, allowing entrepreneurial researchers to address fundamental science and engineering challenges while also receiving business mentorship and entrepreneurial training. This combined focus on both early-stage R&D and entrepreneurial development enables researchers to ready breakthrough ideas for adoption by the private sector. The Department has requested $6.5 million in FY 2019

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

funding for support of new projects led by early-career post-doctoral researchers at the National Laboratories that will support AMO's Lab-Embedded Entrepreneurship Programs at Lawrence-Berkeley, Argonne, and Oak Ridge national laboratories.

Q2. I wanted to ask you to explain the reasoning behind the flat funding proposed for the Scientific User Facility Operations, which covers facilities such as the Advanced Photon Source at Argonne and the Stanford Synchrotron Radiation Light Source. These facilities have been flat funded for a number of years now, meaning that in real terms, their purchasing power is slowly decreasing. The FY19 budget request states that these facilities are funded at 95% of optimum. Given that these research facilities are not only critical to our global scientific leadership but also serve as magnets for science-driven companies to locate nearby, I cannot endorse intentionally under-funding them. The result could be reductions in available user time or shutdown of some analytical interfaces, reducing the amount of science that can be done. At a time when we are investing in major capital upgrades to several user facilities, including the Advanced Photon Source, why are we under-funding operations?

A2. The FY 2019 President's Request for the Basic Energy Sciences (BES) program supports a balanced portfolio of (1) forefront research in condensed matter and materials sciences, chemical sciences, geosciences, and biosciences, (2) the upgrade and construction of world-leading scientific user facilities, and (3) the operation of these facilities. Each facet of this portfolio is essential to maintaining international competitiveness in new materials discovery and chemical processes, which are the foundation for many applications of potential societal benefit. Within available funding, BES can successfully deliver our highest priority investments in facility upgrades while continuing to operate the suite of scientific user facilities and serve the program's mission needs.

Q3. I was pleased to see the emphasis on battery technologies and grid modernization in the budget request, including $90 million for a new "Beyond Batteries" initiative. Given that DOE already has a number of battery technology research and development programs, including the Joint Center for Energy Storage Research at Argonne National Lab, I wanted to ask how the new initiative will be integrated with existing programs for a cross-cutting approach.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A3. As part of the Administration's efforts to increase the reliability and resilience of our energy systems, Beyond Batteries takes a broad, holistic view of energy storage as part of a set of capabilities that enable temporal flexibility in the conversion of energy resources to useful energy services. Batteries, or electrochemical energy storage technologies, are an important technology solution to continue to advance, but there are other options to achieve the same energy services batteries can provide. Beyond Batteries looks at the functions that grid-scale batteries can provide, then focuses on other ways to provide those functions. In this way, it is inspired by the success of previous investments in grid-scale batteries, and builds off of previous work in both the Office of Electricity and the Office of Energy Efficiency and Renewable Energy to effectively mimic many of the benefits of grid-scale batteries.

Beyond Batteries will incorporate the progress made from previous work in each of the individual programs, building off of successful Grid Modernization Initiative projects that cut across DOE offices. For example, controllable loads work in the FY 2019 request concentrates on technologies that enable behind-the-meter devices to provide grid services, including power electronics that incorporate storage controls. This work builds on previous investments in systems integration in the Solar program and in power electronics in the Advanced Manufacturing program to develop new technologies leveraging scalable domestic manufacturing capabilities.

The FY 2019 request also includes work to research, validate, and improve the ability of large, bulk power resources like geothermal and hydropower to operate flexibly over long periods of time and provide essential reliability services. This includes field testing to validate the ability of these resources to respond quickly to electrical demand fluctuations and other grid disturbances. This work builds off of previous investments in the Geothermal program focused on the ramping ability of geothermal plants, as well as work in the Water program on valuation of hydropower and pumped storage.

Finally, the FY 2019 request for Beyond Batteries includes work centered on reliable hybrid energy systems to include technologies and approaches for integrating electric vehicles, hydrogen fuels cells, distributed wind and solar, and building loads.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

QUESTIONS FROM REPRESENTATIVE ROSEN

Q1. For decades, Nevadans have been fighting against our state becoming a dumping ground for the rest of the nation's nuclear waste... citing an array of serious and unresolved public safety and environmental concerns. Yucca Mountain threatens the health and safety of Nevadans... and the millions of Americans who live in the 44 states and 329 Congressional Districts along the proposed transportation routes. Secretary Perry, you and your Deputy Secretary, Dan Brouillette have both stressed the importance of science in evaluating where we should store our nation's nuclear waste. However, your budget request includes $120 million to bring high-level nuclear waste to Nevada.

Q1a. What analysis do you believe is so scientifically justified for your budget to continue to push for Yucca Mountain to be the repository site and to move forward with the re-licensing process at Yucca?

A1a. The Department's License Application (LA), submitted to the Nuclear Regulatory Commission (NRC) in 2008, was supported by thousands of underlying technical reports and analyses that were conducted by the nation's national laboratories, which explain how the Yucca Mountain repository could be safely constructed and operated. The NRC conducted an independent review of DOE's LA, which confirmed the safety of the Yucca Mountain repository. The conclusions of the NRC staff's independent technical review are documented in a multivolume Safety Evaluation Report for a Geologic Repository at Yucca Mountain.

Q1b. Has the Administration performed any further analysis of its own to support this budget request?

A1b. The Administration has not conducted further analysis of Yucca Mountain and stands behind the work submitted to the NRC in the LA. The LA was prepared with support from the national laboratories and was independently validated by the NRC. The Budget Request is sufficient to restart licensing activities.

Q2. In 2015, based on recommendations from the Blue Ribbon Commission on America's Nuclear Future... your predecessor Secretary Moniz announced that DOE would pursue a consent-based approach to site nuclear waste facilities. Unfortunately, this

Administration has completely ignored this precedent and is trying to revive Yucca Mountain… even though the majority of Nevadans oppose the site.

Q2a. Has the Department of Energy, under this current Administration, considered a consent-based approach to storing nuclear waste?

A2a. The current Administration is complying with the Nuclear Waste Policy Act (NWPA), as amended, which established the Federal responsibility and a definite Federal policy for disposal of high-level radioactive waste and spent fuel. The NWPA provides for State, tribal and public participation in the planning and development of a repository. The FY 2019 Budget Request continues the NRC licensing proceeding for a repository at Yucca Mountain.

Q3. Part of DOE's role includes advancing U.S. national security and economic growth. Some proponents of the Yucca Mountain project argue that it will create jobs and help the local economy, which is why I recently introduced the "Jobs, Not Waste Act" – a proactive and innovative proposal to turn Yucca Mountain into something useful, a project that would create jobs without threatening the health and safety of Nevadans and other Americans across the country.

Q3a. Will the Department consider how developing Yucca Mountain could hurt our local economy?

A3a. The Repository Supplemental Environmental Impact Statement (SEIS), issued by DOE in 2008, evaluated the potential socioeconomic impacts of the proposed repository and the associated transportation of spent nuclear fuel and high-level radioactive waste. The SEIS evaluated potential changes to employment, population, housing, public services, and three economic measures (real personal disposable income, spending by state and local governments, and gross regional products). In general, the project would result in increases to: employment, Gross Regional Product, real disposable personal income, and state and local government spending. The complete evaluation of the potential socioeconomic impacts including the potential for perceived risks are described in greater detail in the SEIS.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

Q3b. Would the Department be open to alternative uses of the site, such as those outlined in my bill?

A3b. The LA described ongoing, existing uses of the Nevada National Security Site and the surrounding area. Other uses may be permissible, as long as they do not interfere with the safety and mission of the repository.

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

QUESTIONS FROM REPRESENTATIVE FOSTER

Q1. The Advanced Photon Source at Argonne National Laboratory is a crucial technical resource for scientists and engineers in universities and in industry. This user facility serves thousands of projects each year. The upgrade which is currently underway will allow researchers to explore molecular structures for drug discovery and identify advanced materials for energy and national security.

In your testimony to the committee, you noted that the Budget Request includes funds to support the upgrade to the Advanced Photon Source. I've been pleased by the show of support so far for the upgrade to Argonne's Advanced Photon Source.

However, to make the best use of this critical upgrade, we also need to ensure that the APS has sufficient operations funding. So I was concerned to see that the Fiscal Year 2019 President's Budget Request notes that the APS and other light sources "will continue operations and are supported at 95% of optimum."

Q1a. Secretary Perry, it doesn't make sense to me that we would intentionally fund something at sup-optimal levels. What is the impact of sub-optimal funding on APS operations?

A1. The Fiscal Year (FY) 2019 President's Request for the Basic Energy Sciences (BES) program supports a balanced portfolio of (1) forefront research in condensed matter and materials sciences, chemical sciences, geosciences, and biosciences, (2) the upgrade and construction of world-leading scientific user facilities, and (3) the operation of these facilities. Each facet of this portfolio is essential to maintaining international competitiveness in new materials discovery and chemical processes, which are the foundation for many applications of potential societal benefit. Within available funding, BES can continue to operate the suite of scientific user facilities to meet the needs of our user community while successfully delivering our highest priority investments in facility upgrades and serving the program's mission needs. Maintenance, equipment upgrades, and procurement activities will be deferred to minimize the impact on operations.

Q1b. Can you comment on the efforts at the Office of Science to support upgrades for facilities such as Argonne's Advanced Photon Source, and the importance of continuing these kinds of investments?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A1b. The BES strategy for light sources is informed by three recent reports by the BES Advisory Committee (BESAC): Report on Basic Energy Sciences Facilities Prioritization, Feb. 2013; Report of the BESAC Subcommittee on Future X-ray Light Sources, July 2013; and Report on Facility Upgrades, June 2016. BES plans to provide world leading x-ray scattering facilities based upon the complementary technologies of storage rings and free electron lasers (FEL) across the full spectrum from soft to hard x-rays. The storage ring-based facilities (the Advanced Photon Source at Argonne National Laboratory and, in future plans, the Advanced Light Source at Lawrence Berkeley National Laboratory) are to be upgraded to incorporate new multi-bend achromat (MBA) lattices to increase average brightness by 100-1000x. The Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory is being upgraded to provide new high average brightness capabilities (LCLS-II) in addition to the extreme peak brightness performance. The upgrade is made possible by the use of superconducting linear accelerator technology that will increase the repetition rate from 120 Hz to 1 MHz. These upgrades are essential to maintaining international competitiveness in light sources.

Q2. As you know, I recently worked with Congressman Steve Knight to introduce the Better Energy Storage Technology (BEST) Act to support the development of energy storage technology that is commercially viable and capable of supporting the electrical grid. I appreciate the valuable feedback that National Lab staff were able to provide on the technical aspects of this bill.

This legislation would initiate research that is complementary to the Department of Energy's current efforts in energy storage, including the work conducted at Argonne National Lab through the Joint Center for Energy Storage Research (JCESR).
The Fiscal Year 2019 President's Budget Request includes support for a "Beyond Batteries" initiative within the Office of Energy and Efficiency and Renewable Energy (EERE). Beyond Batteries is described in a few lines and, although it is a cross-cut initiative across multiple EERE program offices, I have not seen a detailed plan for coordination of efforts and how they will complement existing initiatives.

Q2a. Secretary Perry, can you provide this Committee with an explanation of the holistic overview of and detailed plan for the Beyond Batteries initiative?

COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
Questions for the Record Responses from Secretary of Energy Rick Perry
An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019

May 9, 2018

A2. As part of the Administration's efforts to increase the reliability and resilience of our energy systems, Beyond Batteries takes a broad, holistic view of energy storage as part of a set of capabilities that enable temporal flexibility in the conversion of energy resources to useful energy services. Batteries, or electrochemical energy storage technologies, are an important technology solution to continue to advance, but there are other options to achieve the same energy services batteries can provide. Beyond Batteries looks at the functions that grid-scale batteries can provide, then focuses on other ways to provide those functions. In this way, it is inspired by the success of previous investments in grid-scale batteries, and builds off of previous work in both the Office of Electricity and the Office of Energy Efficiency and Renewable Energy to effectively mimic many of the benefits of grid-scale batteries.

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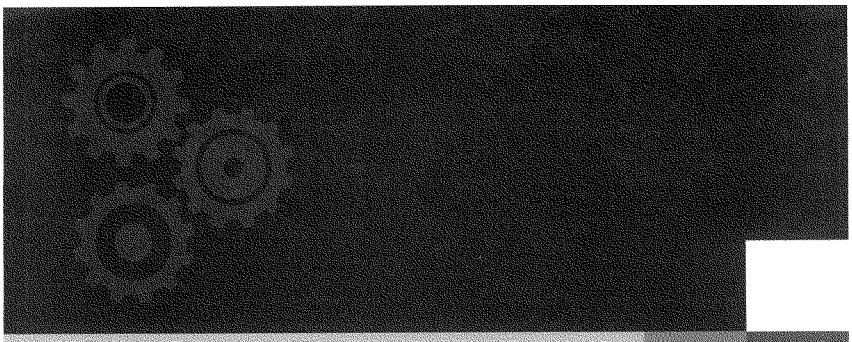


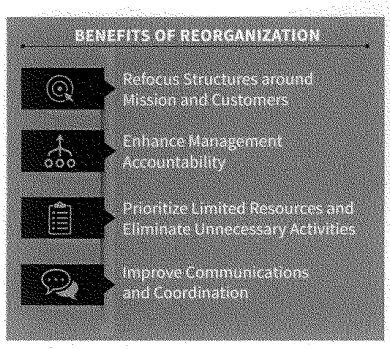
I. THE MANDATE FOR REFORM

INTRODUCTION

When America's Founders wrote the Constitution, they laid out a clear vision for the United States Government: to establish justice, ensure domestic tranquility, provide for the common defense, promote the general welfare, and secure the blessings of liberty. Moreover, they established Executive Branch organizations and structures to deliver on the Federal mission in ways appropriate to America's needs at the time. Over successive generations, our Federal Government has evolved by expanding in scope and complexity to try to meet Americans' needs. However, the organizational structures that underpin the Executive Branch have not always kept pace.

Two decades into the 21st Century, the public still believes that the Federal Government serves critical roles, and in some areas performs them well.[1] However, public trust in the Federal Government has declined over the last decade,[2] calling into question how well the current organizational constructs of Government are aligned to meet Americans' needs in the digital age. Government in the 21st Century is fundamentally a services business, and modern information technology should be at the heart of the U.S. Government service delivery model. And yet, today's Executive Branch is still aligned to the stove-piped organizational constructs of the 20th Century, which in many cases have grown inefficient and out-of-date. Consequently, the public and our workforce are frustrated with Government's ability to deliver its mission in an effective, efficient, and secure way.

At times of great change, the need to reinforce this common commitment to "government of the people, by the people, and for the people"[3] has been critical. So it is not surprising, as the United States faces the challenges of serving the broad and diverse needs of our growing country, that it becomes important to reexamine the organizational alignment of Executive Branch Government institutions to ensure that our organizational constructs are well aligned to meet the needs of the 21st Century.



To that end, Executive Order (EO) 13781, entitled "Comprehensive Plan for Reorganizing the Executive Branch," highlights the need to evaluate the organizational constructs that support today's mission delivery objectives. Building on a history of bipartisan Government reform initiatives, the EO focuses specifically on the role of organizational alignment in reducing "duplication and redundancy," and improving "efficiency, effectiveness, and accountability of the executive branch."[4]

This report outlines the Administration's analysis and recommendations for structural realignment of the Executive Branch to better serve the mission, service, and stewardship needs of the American people. While some of the recommendations identified in this volume can be achieved via Executive administrative action, more significant changes will require legislative action as well.

By sharing key findings, the Administration offers this report as a cornerstone to build productive, bipartisan dialogue around realigning the Federal Government mission delivery model to make sense in the 21st Century. As such, while some of the proposals are ready for agency implementation, others establish a vision for the Executive Branch that will require further exploration and partnership with the Congress.

Finally, reorganization is one tool among many that this Administration is using to drive transformational change in Government. Meeting the needs of the American people, as well as the President's mandate for greater efficiency, effectiveness, and accountability, requires a range of transformational approaches to support reorganization. To that end, the President's Management Agenda (PMA) outlines a range of additional priorities and tools that, in combination, will create an Executive Branch that is prepared to meet the needs of the American people both now and in the future. The Administration welcomes constructive dialogue and consideration of all the tools, capabilities, and organizational principles that help support our mission and better serve the public.

[1] Pew Research Center, December 2017, "Public Trust in Government: 1958-2017."
[2] Pew Research Center December 2017, "Government Gets Lower Ratings for Handing Health Care, Environment and Disaster Response."
[3] President Abraham Lincoln, Gettysburg Address, November 19, 1863.
[4] President Donald Trump, March 13, 2017, speech.